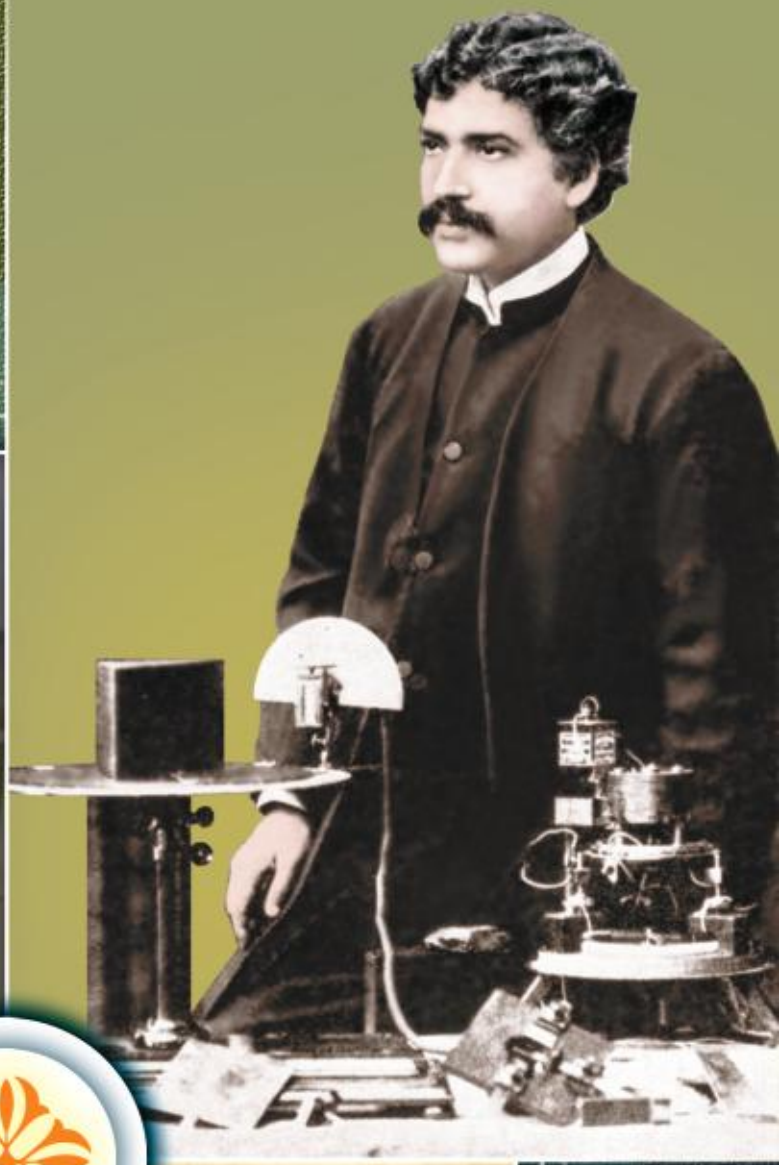
Annual Report

2016-17



Bose Institute

Kolkata

Centenary Lecture

Sir Richard J. Roberts, recipient of the 1993 Nobel Prize in Physiology or Medicine with Phillip Allen Sharp for the discovery of introns in eukaryotic DNA and the mechanism of gene-splicing, delivered the Centenary Lecture on BACTERIAL METHYLOMES on March 27, 2017 at the Lecture Hall, Bose Institute Main campus. The Lecture was followed by a memorable visit to the J.C. Bose Museum.

ANNUAL REPORT OF BOSE INSTITUTE

2016-2017

BOSE INSTITUTE
Kolkata

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

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

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Contents

From the Director's Desk

Siddhartha Roy
Director (Officiating),
Bose Institute

132nd Birthday Celebration of Prof. Debendra Mohan Bose

The 132nd Birthday of Prof. Debendra Mohan Bose was celebrated on November 26, 2016, at the Main Campus Lecture Hall of the Institute. Prof. A.K. Sood, Department of Physics, Indian Institute of Science, Bangalore 560 012, graced the occasion as Guest of Honour and delivered the D. M. Bose Memorial Lecture on the topic "Active Matter : Bio-Heat Engine and Flocking".

Introduction

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

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

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

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

Research Activities

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

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

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

II. Structural Studies and Biophysical Problems

III. Computational Biology

IV. Molecular Medicine

V. Basic and Applied Microbiology

VI. Systems Biology

VII. Basic and Applied Problems in Physical and Environmental Sciences

Academic Manpower Development

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

Science and Society

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

MANAGEMENT OF THE INSTITUTE

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

Members of the Governing Body

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

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

Members of the Finance Committee

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

SCIENTIFIC REPORTS

I

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

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

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

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

Introduction

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

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

Dr. Debabrata Basu

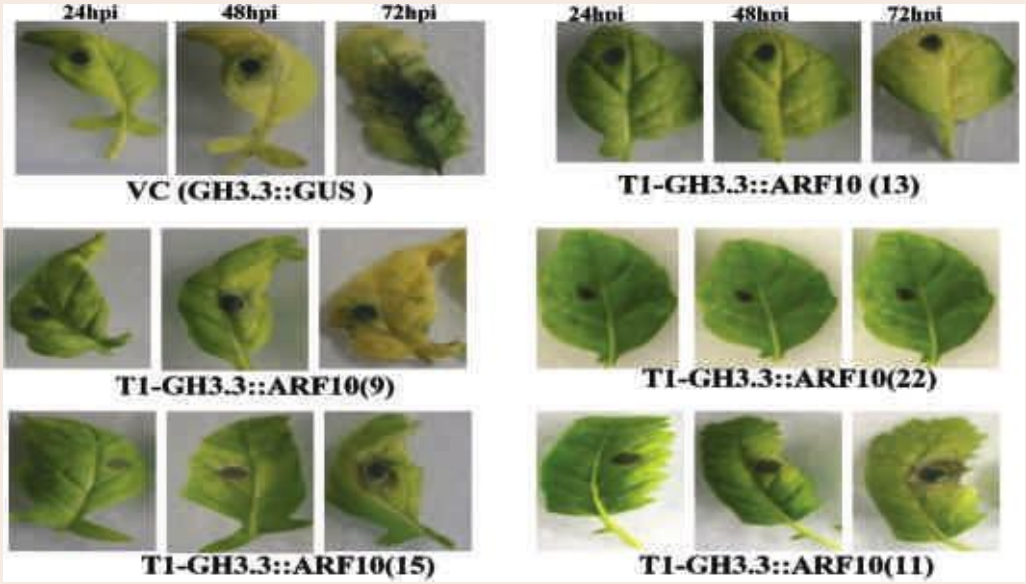
Professor

Scientific Reports

Conditional expression of auxin-responsive transcription factor ARF10 in Indian mustard resulted in abiotic stress tolerance and resistance against *Alternaria brassicicola*

This study aims to find the possible interconnection between resistance against necrotrophic fungal pathogen *Alternaria brassicicola* and abiotic stress tolerance in oilseed mustard. Oilseed mustards

like *Brassica juncea* (Indian mustard), *Brassica rapa*, *Brassica napus* are the major target of 'Black Spot' disease causing necrotrophic fungal pathogen *A. brassicicola* because genetically germplasm of oilseed mustard lack the resistance response genes. However, *Sinapis alba*, a close relative of oilseed mustard, which belongs to the same family *Brassicaceae*, shows a non-host resistance against this pathogen. An early ABA response is found to be responsible for induction of resistant response in *S. alba,* but susceptible *B. juncea* fails to initiate the same response. Moreover, another hormone auxin found to be repressed in *B. juncea* compared to *S. alba*. Therefore, one of the auxin-responsive transcription factors ARF10, which is involved in the ABA-auxin crosstalk and upregulated in resistant *S. alba* compared to *B. juncea* on the challenge with *A. brassicicola* was conditionally expressed in *B. juncea*. Transgenic *B. juncea* plants harbouring the ARF10 gene under the control of *A. brassicicola* inducible promoter of GH3.3 gene were established, and lines in the T1 generation showed enhanced tolerance against *A. brassicicola* as well as enhanced expression of ABA-responsive genes ABI5, NCED3, ABI3 and PYL4. Through protein-DNA interaction studies like florescence quenching, EMSA, ChIP, etc. it was found that ARF10 is capable of binding with the upstream of ABA responsive genes. These evidences confirm that elevated expression of ARF10 causes enhanced ABA response, which attributes the tolerance against *A. brassicicola* and delayed seed germination in the transgenic *B. juncea* lines.



Differential disease progression of GH3.3::AFR10 transgenic *B. juncea* plants upon challenge with *A. brassicicola* at different time points. The T1 lines 13 and 22 showed tolerance compared to lines 9, 11 and 15. VC-T1 transgenic transformed with only vector.

Grants-in-Aid Schemes:

Title of the Scheme	Funding Agency
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

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

Delivered a lecture at the National Symposium on "Current Advances *Molecular Host – Pathogen Interactions (Plants & Animals)*" at NIT, Durgapur on 29 March, 2017.

Group Members:

Banani Mondal, CSIR-SRF presented a poster in the International Symposium 'Insight to plant biology in the modern era' organised by DPB, Bose Institute on "Dual role of NAC domain transcription factors in *Alternaria brassicicola* resistance and abiotic stress responses in oilseed mustard" held on February 8 – 10, 2017. The poster was awarded as one of the Best Poster.

Amrita Mukherjee, SRF presented a poster in the International Symposium 'Insight to plant biology in the modern era' organised by DPB, Bose Institute on "Auxin response factor 10 acts as a connector between abiotic stress and necrotrophic resistance against *Alternaria brassicicola*" held on February 8 – 10, 2017.

Dr. Mrinmoy Mazumder, CSIR-RA presented a poster in the International Symposium 'Insight to plant biology in the modern era' organised by DPB, Bose Institute on "*Alternaria brassicicola* Induced Auxin Repression in Susceptible *Brassica juncea* is Protected Through Enhanced ABA Response in resistant Sinapis alba" held on February 8 – 10, 2017.

Dr. Upala Saha, Assistant Professor, Sister Nibedita Government General Degree for girls, who did her PhD work under the guidance of Prof. D. Basu, DPB presented a poster in the International Symposium 'Insight to plant biology in the modern era' organised by DPB, Bose Institute on "Temporal Increase of Phosphatidic Acid level results in resistance to *Alternaria brassicicola* and ABA response in oilseed mustard" held on February 8 – 10, 2017.

Students awarded PhD:

Name of Student (University/Year)	Title of Thesis
Mrs. Upala Saha C. U., 2016	Identification and Analysis of Auxin Related Signalling Genes Involved in Incompatible Interaction of *Alternaria brassicicola* with *Sinapis alba* L."

Dr. Shubho Chaudhuri

Associate Professor

Scientific Reports

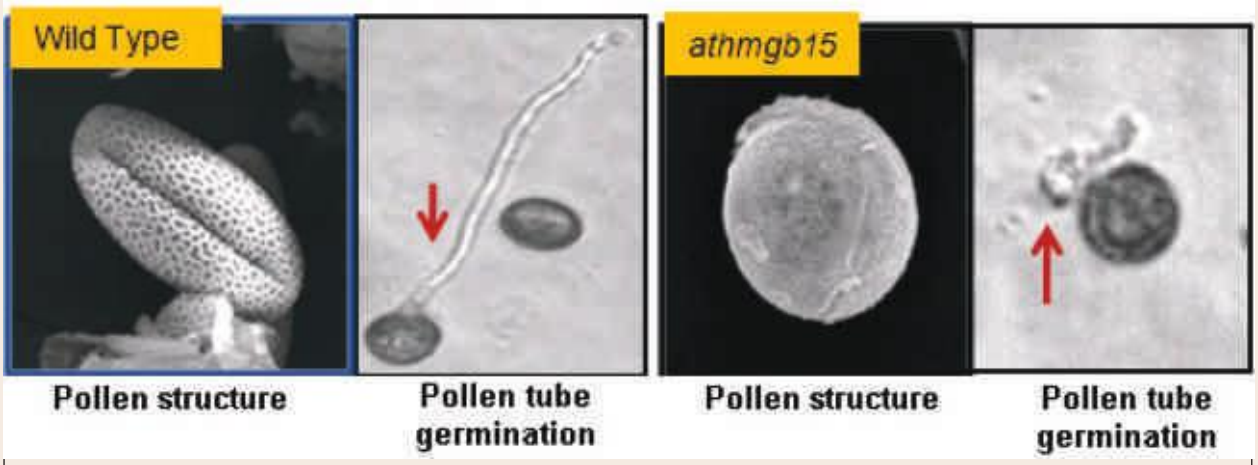
Epigenetic regulations during plants response to different environmental or developmental stimuli

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

ARID/HMG belong to novel class of high mobility group that are only present in plants. This group of proteins has two DNA binding domains: AT-rich interaction domain (ARID) and HMGB-box in a single

polypeptide. Phylogenetic analysis indicates that these proteins were highly diverse in dicot compared to monocots. Biochemical characterization reveals that ARID/HMG protein can bind to varieties of DNA topological structure that includes linear DNA, circular DNA, supercoiled DNA and even the nucleosome. Site-directed mutagenesis has indicated that ARID domain plays an important role in DNA-Protein interaction. These proteins can bend the DNA backbone and can induce negative supercoil in relaxed plasmids.

The protein can promote basal transcription from a supercoiled plasmid in presence of RNA polymerase and sigma factor and this property of the protein is mostly facilitated by HMG-box domain. One of the members of Arabidopsis ARID/HMG protein family, AtHMGB15, shows high tissue specific expression in young and mature flowers. Interestingly, knockout mutant of AtHMGB15 shows mutated pollen structure and retarded pollen tube germination.



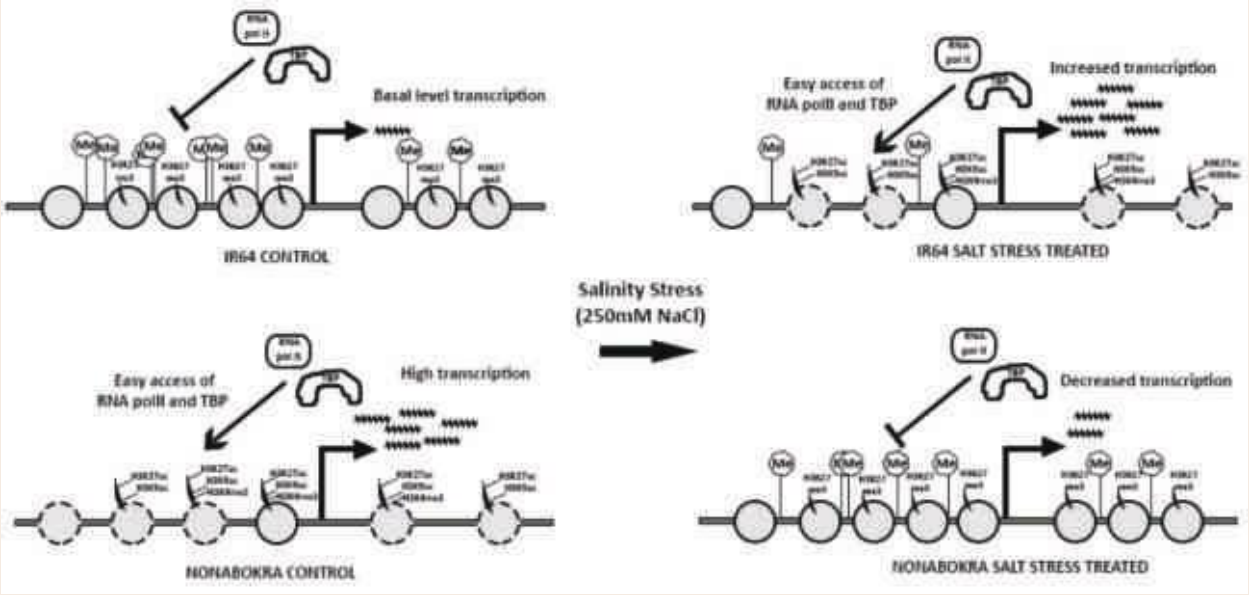
Comparative transcriptome of wild type and *athmgb15* mutant flower tissue indicate 1581 and 1595 genes were upregulated and downregulated in mutant. Many of affected genes were found to be involved in several biological processes like metabolism, cell organization and biogenesis, transcription, cellular transport, developmental processes and signal transduction which are crucial in pollen development pathway as well.

Approaches were taken to find the interacting partners of AtHMGB15 by screening yeast-2-hybrid library made from Arabidopsis seedlings. The result indicates that one of the interacting partners of AtHMGB15 was found to be a RING domain protein encoded by At5g47610. Further characterization indicated that the interacting protein is a E3 ligase containing C2H2 type RING domain and a transmembrane domain. In vitro analysis indicates that RING protein can interact with AtHMGB15 and can ubiquitinate both in vitro and in vivo.

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

Reprogramming of cellular function in response to external stress stimuli is one of the important mechanism by which plants adapt to the environment. Stress adaptation involves alteration in the expression levels of several genes. The highly complex structure of chromatin imparts resistance to

several nuclear processes including transcription. Several covalent modifications at the N-terminal tails of histones and changes in DNA methylation together generate epigenetic code to promote accessibility of nuclear factors to their cognate binding site. Using rice as a system, we have studied different epigenetic changes involved in regulating the expression of stress responsive transcription factor OsBZ8 in two different rice cultivars, IR64 and Nonabokra. Our results indicate that there are differential epigenetic marks at the promoter region of OsBZ8 in response to salt stress in these rice cultivars.



Genome-wide ChIP on chip analysis has indicated differential regulation of Histone H3K27methylation and H3K27 acetylation during cold stress response in rice. The transition of repressive H3K27me3 to activating H3K27ac correlates with the expression of cold stress responsive loci in rice plant.

Publication:

1. Roy A, Dutta A, Roy D, Ganguly P, Ghosh R, Kar KR, Bhunia A, Mukhopadhyay J, Chaudhuri S (2016) Deciphering the role of the AT-rich interaction domain and the HMG-box domain of ARID-HMG proteins of *Arabidopsis thaliana.* Plant Molecular Biology. 92:371–388. DOI 10.1007/s11103-016-0519-y

Students awarded Ph.D.:

Name of the Student (University/Year)	Title of the thesis
Dipan Roy (C.U, 2017)	Elucidating the change in the chromatin structure of the DREB protein coding loci during Abiotic stress

Grants-in-Aid Schemes: :

Title of the Scheme	Scheme funded by
Investigating the genome wide changes in Histone H3K27 acetylation and gene expression in rice during cold stress	DST-SERB
Unraveling the role of PLC in plant drought and heat stress tolerance: Exploring the potential of PI metabolism to improve crop yield. *(PI: Dr. ANL Majumber: Co-PI: Dr. Shubho Chaudhuri)*	DBT-NOW

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

Group Members:

Adrita Roy, SRF presented poster in the international conference "Insight to Plant Biology in the Modern Era" held in Bose Institute from February 8 – 19, 2017.

Rwitie Mallik, SRF presented poster in the international conference "Insight to Plant Biology in the Modern Era" held in Bose Institute from February 8 – 19, 2017.

Pratiti Dasgupta, JRF presented poster in the international conference "Insight to Plant Biology in the Modern Era" held in Bose Institute from February 8 – 19, 2017.

Seminars / Symposia organized at Bose Institute:

(I) Member and joint Treasurer of National symposium on "Transcription assembly, 2016" at Bose Institute Kolkata held on November, 2016; (ii) Member and joint Treasurer of International symposium on "Insight to Plant Biology in the Modern Era" 2017 at Bose Institute Kolkata held on February, 2017.

Dr. Sampa Das

INSA Senior Scientist

Scientific Reports

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

Chickpea, the third most important pulse crop of the world becomes highly popular to all concerned for its unique nitrogen fixing ability and high nutritive value. Unfortunately, the crop suffers from various pests and pathogen attack. A number of transgenic Bt endotoxin expressing chickpea plants were developed which demonstrate significant resistance against pod borer, the serious insect pest of chickpea. The other major pathogen severely affecting the crop by causing

wilt disease is *Fusarium oxysporum.* Development of wilt resistance in chickpea becomes difficult as there is no resistant gene(s) available until now. Hence, we employed transcriptomic and proteomic approaches to understand chickpea defense response mechanism against *Fusarium*.

Transcriptomic dissections of wilt susceptible (JG62) and resistant (WR315) genotypes of chickpea upon *Fusarium* inoculation generated a large number of differentially expressed transcripts from infected as well as uninfected susceptible and resistant chickpea plants. Significant differential transcripts between susceptible infected and mock infected plants were 2090 while between resistant infected and control plants were 881. Gene ontology based analyses and metabolic network analyses identified numbers of defense related components like peptidyl cis/trans isomerase, MAP kinase, Beta 1,3 glucanase, Serine threonine kinase, Patatin like protein, lactolylglutathione lyase , Coproporphyrinogen III oxidase, Sulfhotransferases; Reactive oxygen species regulating components such as respiratory burst oxidase, superoxide dismutases, cytochrome b5 reductase, glutathione reductase, thioredoxin reductase, ATPase; metabolism regulating components like, myo inositol phosphate, carboxylate synthase; transport related component like gamma tonoplast intrinsic protein, and structural component like ubiquitins to serve as important nodals of the defense signaling network. Such analyses grossly divided the differentially expressed transcripts into three groups across (1) biological process, (2) molecular function and (3) cellular components. Further analyses through development of metabolic mapping of the differentially expressed transcripts are underway.

Likewise, proteome of four sets of samples as mentioned above were analysed individually in 2-D PAGE. Dfferentially detected protein spots were analysed by LC MS/ MS and identified as Chitinase; 14-3-3 protein; pathogen related protein –PR10; ATP synthase. Further characterizations of these proteins and determining their coding sequences are being done.

Publications:

1. Bhar A, Gupta S, Chatterjee M and Das S (2017) Differential expressions of photosynthetic genes provide clues to the resistance mechanism during *Fusarium oxysporum* f.sp. ciceri race 1 (Foc1) infection in chickpea (*Cicer arietinum* L.) *European Journal of Plant Pathology*.DOI 10.1007/s10658-016-1109-1.
2. Bhar A, Gupta S, Chatterjee M and Das S (2017) Redox Regulatory Networks in Response to Biotic Stress in Plants: A New Insight Through Chickpea-*Fusarium* Interplay. *In Mechanism of Plant Hormone Signalling under Stress*. (Ed-Girdhar K. Pandey) DOI: 10.1002/9781118889022.
3. Sen S and Das S (2016) Role of HD-Zip transcription factors in plant development and stress responses, *International Journal of Agriculture, Environment and Biotechnology* 9 (5), 711-718.

Students awarded Ph.D. :

Name of the Student (University/Year)	Title of the thesis
Ayan Das C.U., 2017	Expression of *Colocasia esculenta* tuber agglutinin (CEA) in Indian mustard (*Brassica juncea* L.) with an aim to develop resistance against sap sucking insect pest

Grants-in-Aid Schemes:

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

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

(I) Delivered an invited talk at MS Swaminathan Research Foundation, Chennai on "*Deciphering the key molecules involved in below ground host resistance response in chickpea- Fusarium interplay*" in a conference organized in the occasion of International *Year of Pulses* on 24 July, 2016; (ii) Delivered lecture at Vivekananda Institute of Technology, Nimpith, West Bengal in a Science Camp under DST Inspire Internship Programme on a topic "*Biotech Crops for Better Tomorrow*" on 20 September, 2016; (iii) Attended and delivered an invited talk entitled "*Regulatory modules controlling below ground Fusarium wilt response at early time point of pathogen infection in chickpea* at Gwalior in the XL All India Cell Biology Conference & International Symposium on "*Functional Genomics and Epigenomics*" during 17 – 19 November, 2016; (iv) Delivered invited talk entitled "*Transcriptional network regulated by HD-Zip TF during plant immune response"* in an International Symposium on The Green Planet : past, present and future in the Department of Botany, Calcutta University, during 21 – 23 December, 2016; (v) Delivered two lectures on "*Plant transcription factors, the key regulators of plant development & stress response" and "Insight to plant immunity: A functional genomic approach"* in the Winter School in Biological Science organized by Department of Botany, Burdwan University, on 21 January, 2017; (vi) Attended and chaired a session in the International Symposium on "*Insight to Plant Biology in the Modern Era*" organized by Plant Scientists of Bose Institute in relation to the centenary celebration of the Institute during 8 – 10 February, 2017; (vii) Delivered an invited talk entitled "*Impact of oligomerization dynamics on functionality of an insecticidal protein"* and chaired a session in a National Symposium on Plant Biotechnology: Current perspectives on medicinal and crop plants & 38th Annual meeting of Plant Tissue Culture Association (India) during 3 – 5 March, 2017; (viii) Delivered an invited lecture entitled " Designing of a novel protein having impact on crop biotechnology" on 29 March, 2017 in a Colloquium organised by Department of Biotechnology, Burdwan University in DBT supported programme.

Seminars / Symposia organized at Bose Institute:

(Organized a Workshop on *"Science and regulation of GM Food and Environmental Safety"* at Bose Institute, on 7 September, 2016 with full support from Department of Biotechnology, Ministry of Science and Technology, Government of India. Prof. S Roy, Director , Bose Institute welcomed the participants, Mr. Craig Hall, Consul General, US inaugurated the session while Dr. S.R. Rao, Advisor, DBT described about the purpose of the meeting. Jonn P. Slette, Senior Attache for Agricultural Affairs, U.S. Embassy, New Delhi opened the Technical Programme. Dr. Julian Adams Departments of Molecular Cellular and Developmental Biology and Ecology and Evolutionary Biology at the University of Michigan, Dr. Carrie McMahon, Center for Food Safety

and Applied Nutrition, United States Food and Drug Administration, USA , Dr. Pham Van Toan Vietnam Academy of Agricultural Sciences (VAAS), Vietnam, Prof. Swapan Dutta, Pro-Vice Chancellor, Visva Bharati University and few more delegates from Bangladesh Agricultural ministry have discussed about risk, benefits and future guide lines for taking forward the genetically modified crops.

Awards / Honors received:

Ms. Sernjuti Sen, a SRF from Sampa Das's group received the Prof. B.B.Biswas outstanding student award on 30 November, 2016.

Mr. Ayan Das a SRF from Sampa Das's group received award for selected best poster presentation in the International Symposium on "Insight to Plant Biology in the Modern Era" on 10 February, 2017.

Social relevance :

Sampa Das's group is actively involved in developing transgenic crops for protecting them from insect and pathogen attack as well as monitoring whether any biosafety related issues are associated with those transgenics.

This endeavor would develop awareness among the stakeholders in the development of scientific methods and protocols for risk assessment and for enhancing competence to review/ audit risk assessment. This also would disseminate information from the research laboratory to research field for further move for exploiting the commercial potentiality which has tremendous societal relevance.

Dr. Akansha Jain

SERB, DST, Young Scientist

(*Mentor: Dr. Sampa Das*)

Scientific Reports

"Proteomics approach to study the resistance response induced in rice treated with beneficial microbes upon challenge with *Xanthomonas oryzae"* (YSS/2015/00773)

Beneficial microbes may protect plants from large number of phytopathogens by either directly inhibiting pathogen or indirectly by inducing systemic resistance. The interaction between plants and beneficial microbes may modulate different regulatory signals, of which only few are detected till date. The signals produced in plants can be highly influenced by interacting microorganism, which may cause both up and down regulation of defense genes and proteins, helping in visualizing a better picture of this complex multi-species interactions occurring in the rhizosphere. Biological management is the only strategy that is economically feasible to reduce the inoculum potential of plant pathogens. Bacterial and fungal isolates were isolated from rhizospheric soil samples collected from various regions in West Bengal. Evaluation of potential biocontrol agents

(BCAs) against *Xanthomonas oryzae* pv. *oryzae* and *Rhizoctonia solani* was carried out *in vitro* using dual culture plate assay. Among 70 bacterial and fungal isolates tested, 25 isolates reduced the growth of phytopathogens significantly. Based on these results 5 bacterial and 9 fungal isolates were selected for 16s rDNA and ITS sequencing, respectively. Compatibility test between efficient bacterial BCAs was performed *in vitro* on agar plates and *in vivo* on rice seedlings by assessing plant growth. Seedlings of rice were surface sterilized and treated with BCAs either singly or in consortia. Effect of treatments on defense-related enzymes phenylalanine ammonia-lyase, peroxidase and polyphenol oxidase and total phenolic content was assessed after pathogen challenge. Real-time quantitative PCR was performed using defense related primers to evaluate up and down regulation of defense related genes in BCA treated and pathogen inoculated plants. The study will help us to know how plants treated with beneficial microbes challenged with pathogen trigger differential stress response and will suggest how these BCA treated plants may act superior in combating the upcoming pathogenic ingress.

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

Attended DST Sponsored Training Program on "Proteomics Approaches for Women Scientists in Life Sciences" held on Feb. 04-08, 2017 at Banaras Hindu University, Varanasi.

Dr. Subha Das

SERB-DST Young Scientist

(*Mentor: Dr. Sampa Das*)

Scientific Report

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

The principal objective of my current research is to identify, characterise and evaluate the potential of mycoviruses in controlling *Rhizoctonia solani* AG-1-IA, the fungal pathogen responsible for sheath blight of rice in India. Fungal isolates (over 100) were collected and characterised (based on ITS and IGS1 sequencing) from rice plants showing typical symptoms of sheath blight from at least 10 different rice-growing states in India. Selected isolates have also been tested for their hyphal growth, somatic compatibility, comparative pathogenicity (on rice) and sensitivity towards fungicides that are being used commonly by farmers in India. Results suggested that AG-1-IA population in India is apparently not highly diverse. Molecular characterisation of total dsRNAs from several *R. solani* AG-1-IA and *R. oryzae-sativa* isolates revealed that mixed viral infection is very common in these fungi. At least five different viruses were found in a single isolate of AG-1-IA. Interestingly, irrespective of location of isolation, presence of a bipartite dsRNA virus was found very common among majority of the AG-1-IA isolates tested. It could be possible that this virus is associated with the fitness of this fungus. The influence of this particular virus on host biology is being investigated.

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

Attended and presented paper in International Conference on Global Perspectives in Virus Disease Management, VIROCON 2016 during December 8 – 10, 2016, organised by Indian Virological Society (IVS) at Indian Institute of Horticultural Research, Bengaluru,

Dr. Gaurab Gangopadhyay

Associate Professor

Scientific Reports

Validation of allele specific CAPS marker of chalcone synthase gene in Indian Mulberry

We have earlier used chalcone synthase (CHS) as a candidate gene in mulberry and developed Single Nucleotide Polymorphism (SNP) based co-dominant Cleaved Amplified Polymorphic Sequence (CAPS) marker associated with the CHS locus. Differential CHS activity of the recombinants was correlated with the segregation pattern of the marker. To validate the marker we have screened F_1 recombinant mulberry population for infection with powdery mildew and assigned to different degree of disease severity. Based on the characteristics of asexual state and host specification, the fungus was identified as *Phyllactinia sp.* The degree of disease severity varied in the heterozygous and homozygous plants with respect to *CHS* locus. The maximum number of homozygous plants restricted the severity of the infection, while the disease severity was high in most of the heterozygous plants. The statistical distribution curve showed a distinct skewing of mean of disease severity between homozygous and heterozygous plants with respect to *CHS* locus.

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

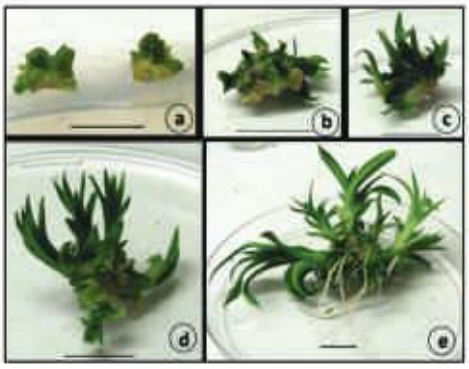
The lignan content of oil of two parents (*S. indicum* and *S. mulayanum*) and a portion of the F_2 population (24 recombinants) was quantified by spectrophotometer and HPLC. Promising recombinants with high oil content (like *S. indicum*, the female parent) containing high lignan (sesamin and sesamol, like *S. mulayanum*, the male parent) were identified. We have also looked for the key regulatory genes in the sesame lignan biosynthetic pathway – some of the identified genes are as follows: Sesamin synthase and two CYP81Q1 homologs from different *Sesamum* spp. We are trying to establish the credential of these genes as candidates for allele-specific marker development to identify the desired recombinants with better oil content and profile.

Isolation and characterization of BADH2 gene from *in vitro* propagated *Pandanus amaryllifolius* Roxb.

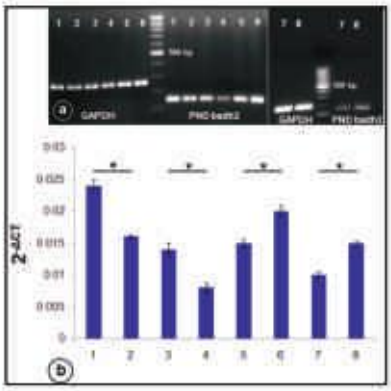
The 2-acetyl-1-pyrroline (2AP) induced 'basmati rice' aroma is plausibly the highest among the plant kingdom in *Pandanus amaryllifolius* Roxb. The defective/truncated allelic form of betaine aldehyde dehydrogenase (BADH2) gene is the major contributing factor behind the accumulation of this fragrance. The present study reports the isolation and characterization of the full-length

BADH2 gene from *P. amaryllifolius* Roxb. The *in silico* analysis involving homology modelling and docking studies revealed the deficiency in catalytic efficiency of *Pandanus* BADH2 towards its substrate γ-aminobutyraldehyde (GAB-ald) as compared to the functional BADH2 gene of rice. We have also studied the tissue-specific expression of the BADH2 gene in different plant parts of *in vivo* donor and *in vitro* propagated *P. amaryllifolius* Roxb. In addition to the leaves, we are reporting histochemical localization of 2AP for the first time in the roots of *P. amaryllifolius*.

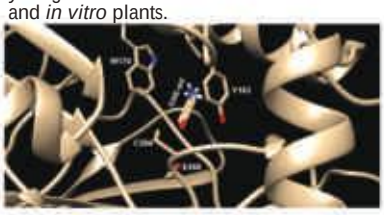
(a) *in vivo* and (b) *in vitro* propagated plants of *Pandanus amaryllifolius*



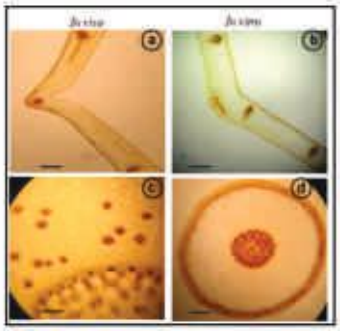
Consecutive stages of *in vitro* multiplication (a - e)



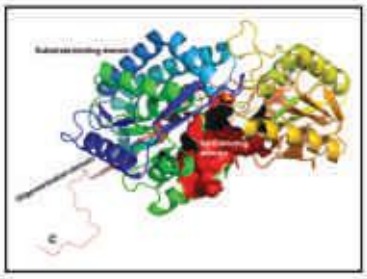
(a) Gel showing amplicons of PND badh2 gene and GAPDH as constitutive gene. (b) Results of qPCR analysis : GAPDH nomalized PND badh2 gene expression in young and mature leaves and roots *in vivo* and *in vitro* plants.



Docking prediction of the substracte GAB-aid with template Pandanus BADH2. The residues Tyr-163, Trp-170, Cys-294 and Glu-260 form the substrate binding pocket and are marked showing interaction with GAB-aid.



Histochemical localization of 2AP in leaves (a, b) and roots (c,d) of P. amaryllifolius ; bars represent 10 µm



The three-dimensional structure of BADH2 of Pandanus showing different domains, coloured by rainbow N → C terminus.

Isolation and characterization of BADH2 gene from in vitro propagated Pandanus amaryllifolius Roxb., a unique wild plant containing 2-acetyl-1-pyrroline (2AP) induced 'basmati rice' aroma : Figures from publication – Arora V, Sultana M, Kumar V and Gangopadhyay G (2017) Plant Cell Tissue and Organ Culture OI 10 1007/s 11240-017-1209-4.

Publications :

1. Arora V, Sultana M, Kumar V and Gangopadhyay G (2017) Isolation and characterization of BADH2 gene from *in vitro* propagated *Pandanus amaryllifolius* Roxb. *Plant Cell Tissue and Organ Culture*. doi: 10.1007/s11240-017-1209-4. Impact factor 2.390 (2015)
2. Gangopadhyay G (2016) From tolerance to disease resistance in mulberry: Need for efficient phenomic and molecular selection tools. *Journal of Environment and Sociobiology* 13(2): 163-168. Impact factor 0.342 (2015)
3. Laha S and Gangopadhyay G (2016) SNP based haplotyping towards development of salt tolerant rice. *Heritage* 3: 153-158.

GenBank Submission:

1. Arora V, Sultana M, Kumar V and Gangopadhyay G (2017) *Pandanus amaryllifolius* betaine aldehyde dehydrogenase (BADH2) mRNA, complete cds. GenBank Accession Ky765936.

Student awarded Ph.D. :

Name of the student (University/ Year)	Title of Thesis
Ms Ranjana Prasad (C.U., 2016)	"Study on Genetic Diversity of Sesame (*Sesamum indicum* L.) for Development of Improved Genotypes by Marker Assisted Selection", Department of Botany, University of Calcutta on 25.10.2016

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

(i) Acted as the Resource person of Plant Science in the North-Eastern States Students' Training on Basic Science 2016 (NESST-BASE 2016) at Mayapuri Campus of Bose Institute, Darjeeling from May 2 – 4, 2016. Compiled and prepared the booklet for the trainees; (ii) Participated in the Awareness Workshop on "GM crops and food and environmental safety" held at Bose Institute in collaboration with DBT, Govt of India on July 9, 2016; (iii) Participated in the One Day Symposium on "The world of microbes: Pathogenesis, Environment and Evolution" on October 17, 2016 organized by Department of Microbiology, Bose Institute held at CB, Bose Institute iv)Participated in the meeting on "Awareness and Discussions on Provisions of Biological Diversity Act, 2002 & Rules" organized by West Bengal Biodiversity Board on November 8, 2016; (v) Organized a Hands-on-Training programme on "Diagnostics of Medicinal potential and DNA fingerprinting in plants" as a 'Core committee member' from November 1 – 15, 2016 as a part of the Centenary Celebration of Bose Institute. Coordinated the Technical session I on November 02, 2016 (DNA isolation from Catharanthus and Murraya), Technical session II on November 3, 2016 (Assessment of quality and quantity of genomic DNA extracted from *Catharanthus* and *Murraya*.), Technical session VIII on November 8, 2016 (RAPD & ISSR(and Technical session X on November 9, 2016 (Elution and purification of PCR products). Delivered lecture to the trainees on November 7, 2016 entitled "Molecular-marker-assisted improvement of plants of known medicinal importance"; (vi) Organized a Hands-on-Training programme on "Basic and Applied Biological Sciences for the High School Students" at MEF (Madhyamgram Experimental Farm) as 'the Convener' from November 22 – 24, 2016 as a part of the Centenary Celebration of Bose Institute; (vii) Acted as one of the Joint Secretaries in the International Symposium on "Insight to Plant Biology in the modern era" (February 8 – 10, 2017) organized by Division of Plant Biology in connection to the Centenary Celebration of Bose Institute; also acted as one of the coordinators in the poster session.

Group Members :

(i) Vivek Arora presented poster entitled "Nitrate Reductase: A Potential Yield-related Trait in Mulberry (*Morus spp*.)" by V. Arora, M. K. Ghosh and G. Gangopadhyay in the International Symposium on "Insight to Plant Biology in the modern era" (February 8 – 10, 2017) organized by

Division of Plant Biology in connection to the Centenary Celebration of Bose Institute; (ii) Sourav Bose presented poster entitled "Morphological and Molecular Characterization of 12 Cultivars of Orchid (*Vanda spp*.)" by S. Bose, G. Gangopadhyay and S. R. Sikdar in the International Symposium on "Insight to Plant Biology in the modern era" (February 8 – 10, 2017) organized by Division of Plant Biology in connection to the Centenary Celebration of Bose Institute; (iii) Anirban Jyoti Debnath presented poster entitled "Standardization of *in vitro* Adventitious Shoot Organogenesis in Sesame (*Sesamum indicum* L.) cultivar JK-1 and the associated role of Abscisic Acid in Organogenesis" by A. J. Debnath, G. Gangopadhyay, D. Basu and S. R. Sikdar in the International Symposium on "Insight to Plant Biology in the modern era" (February 8 – 10, 2017) organized by Division of Plant Biology in connection to the Centenary Celebration of Bose Institute; (iv) Vivek Arora presented poster entitled "Development of chalcone synthase locus specific CAPS marker to screen abiotic stress tolerant mulberry genotypes from a recombinant population" by V. Arora and G. Gangopadhyay in the International Symposium "InterDrought-V" (February 21 – 25, 2017) at Hyderabad (organized by ICRISAT, USAID and ICAR). v) Debabrata Dutta presented poster entitled "Marker assisted selection and phenotyping of an inter-specific hybridization derived population towards development of sesame with synchrony in pod maturation for drought avoidance" by D. Dutta and G. Gangopadhyay in the International Symposium "InterDrought-V" (February 21 – 25, 2017) at Hyderabad (organized by ICRISAT, USAID and ICAR) (vi) Sourav Bose presented poster entitled "Isolation and characterization of HSPRO2 – a defense gene from Rorippa indica (L.) Hiern a wild relative of cultivated crucifers" by S. Bose, G. Gangopadhyay and S.R. Sikdar in the National Symposium on Plant Biotechnology: Current Perspectives on Medicinal and Crop plants (March 3 – 5, 2017) organized by Plant Tissue Culture Association (India) held at IICB, Kolkata.

Talks delivered at other Institutions :

Delivered invited lecture entitled "From tolerance to disease resistance in mulberry: need for efficient phenomic and molecular selection tools" in the UGC sponsored National level seminar on "Socio-economic impact of integrated disease management in sericulture in the tribal villages of West Bengal", organized by Department of Agriculture and Rural Development, Chandraketugarh Sahidullah Smriti Mahavidyalaya on September 01, 2016; also acted as one of the National Advisory Board Members of the said seminar; (ii) Delivered an invited talk in the Special Winter School in Chemical Science and Technology organized by UGC-Human Resource Development Centre (HRDC), University of Calcutta on February 21, 2017; (iii) Delivered an invited talk in the Science Academies' Lecture Workshop on "Recent Trends in Chemistry and Biology" organized by Science Forum, Mrinalini Datta Mahavidyapith, Birati, Kolkata; sponsored and supported by Indian Academy of Sciences, Bangalore, Indian National Science Academy, New Delhi and The National Academy of Sciences, India, Allahabad on March 06, 2017.

Awards / Honors received :

Invited to act as one of the mentors in the DST-INSPIRE Internship Science Camp 2016 organized by Vivekananda Institute of Biotechnology, Sri Ramakrishna Ashram, Nimpith; conducted the Hands-on programme on the theme: "*A glimpse of the biological research of Acharya J C Bose*" on September 22, 2016.

Dr. Anupama Ghosh

Assistant Professor and DST-Inspire Faculty

Scientific Reports

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

The key to successful colonization of host plants by a phytopathogenlies in its ability to overcome host defense responses. *Ustilagomaydis* genome exhibits a rich repertoire of genes coding for defense proteins that possibly aids the pathogen in not only acclimatizing with the host environment but also colonizing host tissue and subsequent infection development. This project is aimed at understanding such defense mechanisms of the pathogen that are activated during host cell invasion. Our study till now involved detailed investigation on two very important classes of proteins that have well established roles in regulation of stress induced programmed cell death in higher eukaryotes and to some extent in many lower eukaryotes. Among them, UmMca is the only metacaspase of *U. maydis* for which we could establish a dual function including a role in maintenance of protein homeostasis within an unstressed cell. In response to stress, however, UmMca could be noticed to function as an executioner of apoptosis like programmed cell death in *U. maydis*. Besides UmMca, small heat shock proteins are also being investigated for a role in survival of the pathogen under conditions of stress during its in-planta growth.

Functional characterization of *U. maydis* effector proteins

Secreted effector proteins constitute an arsenal of extracellular virulence factorsfor a phytopathogenic fungi that aid in dampening host defense responses thereby enabling the pathogen to establish the disease. These effector proteins although can be categorized into many enzymatic classes most of them do not show any obvious catalytic or structural domains leading to their classification as hypothetical proteins. In this project we are putting efforts to systematically characterize some of the selected enzymatic classes of computationally predicted effector proteins of *Ustilagomaydis*. For this study we are relying primarily on genetic studies involving genes coding for the respective effector proteins.

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

This project is aimed to study the extracellular proteome of rice in relation to infection by *Rhizoctoniasolani*. This study is aimed at investigation of both the secretome of *R. solani* during host invasion as well as plant defense proteins involved in plant defense against sheath blight. Attempts are also being made to establish a genetic toolbox for *Rhizoctoniasolani* that would enable us to undertake reverse genetic studies in the pathogen.

Publication :

Book Chapter

(i) Ray D, Ghosh A, Banerjee Mustafi S, Raha S (2016) Plant stress response: HSP70 in the spotlight. Book “Heat shock proteins and plants”, Springer publishers.

Grants-in-Aid Schemes:

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

Dr. Swagata Ghosh

DST Women Scientist (WOS-A)

Scientific Report

Development of functional genetic markers of Indian Mustard linked to the candidate resistance genes against *Alternaria brassicicola*

Brassica juncea (Indian mustard) is a major oilseed crop of India. The 'Black Spot' caused by *Alternaria brassicicola* is the most established disease of *Brassica* worldwide. To date, no resistant oilseed variety against this disease has been reported. Therefore, assessment of quantitative basal resistance among the susceptible *Brassica juncea* lines has been addressed, and 47 diverse *B. juncea* varieties were screened by artificial inoculation of *A. brassicicola* spores keeping *Sinapis alba* (B1D) as the positive control. Based on the rate of lesion development, two varieties of *B. juncea* that showed significantly slower lesion development compared to other cultivars were identified. Quantification of disease progression by real-time monitoring of the *Alternaria* specific 5.8S rRNA genomic sequence amplification from the different varieties of *B. juncea* and *S. alba* leaves at different time points on the challenge with *A. brassicicola,* indicated an extremely high rate of hyphal growth in the cultivars compared to *S. alba* and two identified tolerant varieties. Since ABA and auxin responses are very important for resistance against *A. brassicicola*, so expression pattern of the genes like NCED3, ABI5 and ARF10 were monitored in *B. juncea* varieties and *S. alba* on the challenge with the pathogen. The enhanced expression of NCED3, ABI5 and ARF10 was observed in *S. alba* and two tolerant varieties compared to the complete down-regulation in susceptible cultivar at different time points. The up-stream regulatory sequence of NCED3 gene was compared among tolerant and susceptible varieties, and two SNPs were identified. Based on morphological, molecular markers, yield attributing parameters one tolerant variety, and one popular cultivar were selected as the diverse parental pairs. A mapping population was developed by crossing which will be used for validating the newly identified SNPs of up-stream regulatory elements of candidate genes.

Presentation: Poster presentation in the International Symposium 'Insight to plant biology in the modern era' organised by DPB, Bose Institute held on February 8-10, 2017, on "Identification of Allele-Specific SNPs from the Up-stream Regulatory Elements of the Candidate Resistance Gene against Alternaria brassicicola in a Diverse set of *Brassica juncea* Genotypes.

Dr. Swati Gupta Bhattacharya

Senior Professor

Scientific Reports

In the last few years we have done detail characterization of predominant outdoor allergens from profusely found pollen grains of common avenue plants such as periwinkle, coconut, *Lantana camara* and sunflower. Common indoor allergens have also been characterized from spores of ubiquitously present molds like *Rhizopus oryzae* and *Curvularia pallescence*. These studies include (i) serolo gical detection and proteomic identification of the allergens, (ii) recombinant production and purification of the allergenic proteins from the respective sources, (iii) frequency of IgE-antibody interaction with these allergens, (iv) mapping the antigenically active molecular domains on the surface of these allergens (i.e. IgE-epitopes) and (v) construction of safe version of these allergens (also known as hypoallergenic immunogens) to be used for immunotherapeutic vaccination. The research work pursued/being pursued in my laboratory has biomedical importance to combat allergic diseases. Since the clinical translation of these findings will improve the molecular diagnosis and therapeutic measures of allergy. Till now, we have reported four major allergens, which have been given the official nomenclature (first 3 letters of the genus name followed by the first letter of the species name and then a numerical which denotes the order of discovery) by the International Union of Immunological Societies (IUIS) such as Coc n 1 from coconut (*Cocos nucifera*), Rhi o 1 and Rhi o 2 from *R. oryzae*, and Cat r 1 from periwinkle pollen (*Catharanthus roseus*). From Coconut pollen we have identified Coc n 1 - a vicillin like protein with characteristic cupin fold. This allergen was purified in natural form from the pollen and as well as recombinantly produced in *E. coli*. Most interestingly it was observed that this protein has a hexameric assembly in which the immune-reactive region is masked by the adjacent subunits, whereas upon denaturation and separation of each subunit the IgE-binding domain gets unmasked. In Rhi o 1, using a combinatorial approach consisting of in silico prediction and experimental validation with synthetic peptides, we identified a novel immunodominant non-cross reactive epitope on its surface. This epitope comprises two peptides, which are distantly located on either end (N-terminal and C-terminal) of Rhi o 1, but in the folded conformation, these peptides come in proximity to make a huge antigenic patch. We identified the critical residues in this epitope, which upon alanine substitution resulted in a 100 fold decrease in the IgE-binding strength and attenuated allergenic activity of the WT allergen in vitro and in vivo mouse model. This epitope mutant version of Rhi o 1 however remained immunogenic as evident from its lympho-proliferation capacity and strong IgG inducing capacity in rabbit. This polyclonal IgG was specifically directed towards the IgE epitope of the allergen and thereby acted as blocking antibody. We concluded that this multiple mutant version of the molecule is a candidate molecule to be used for specific immunotherapy or SIT.

We have serologically detected the major IgE-reactive proteins from prawn and brinjal blot using patient sera. We have identified two proteins from each sample with frequent allergenic activity. Apart from this, to screen the allergens in larger scale we have created the cDNA expression library of brinjal for immunoscreening. A 16 kD profilin allergen from brinjal and a ~ 28 kD tropomyosin allergen from prawn muscle have been PCR amplified and cloned in expression vector. Further work on characterization of these two allergens is in progress.

Publications :

1. Chakraborty P, Ghosal K, Sarkar E and Gupta Bhattacharya S (2016) Atmospheric pollen grains of a suburban area near India–Bangladesh border with reference to their allergenic potential and probable effect on asthma-related hospital admission, *Current Science.*111(9) : 1486-1491,Impact Factor – 0.9
2. Ghosal K, Saha B, Gupta Bhattacharya S (2016) Clinical and immuno-proteomic approach on *Lantana camara* pollen allergy-a major health hazard, *Allergy Asthma Clin Immunol.* 28; 12:33, Impact Factor – 2.2

Awards and honours :

Acted as i) Organizing Secretary of the International Symposium on "*Insight to Plant Biology in modern era*" as part of Centenary celebration organized by Division of Plant Biology, Bose Institute in February 2017 and also chaired a session named "*Impact of Plants on Human Health*" ii) Secretary of the Local Organizing Committee of the 19th National Conference of Indian Aerobiological Society [NCIAS-2016] at Bose Institute, December 2016 iii) Elected as Sectional President (Environmental Sciences section) of Indian Science Congress, 2016 at Tirupati, Andhra Pradesh and delivered the Presidential lecture.

Group Members:

Mr. Gaurab Sircar (SRF, Division of Plant Biology) working under Prof. Swati Gupta Bhattacharya presented an abstract and received Outstanding Abstract Award in World Allergy Organization International Scientific Conference - 2016 (WISC – 2016) held in Jerusalem, Israel from 6 – 9 December, 2016.

Bodhisattwa Saha (SRF, Division of Plant Biology) working under Prof. Swati Gupta Bhattacharya attended 104th Indian Science Congress (January 3 – 7, 2017) at Tirupati , India , gave an oral presentation, and won the ISCA Young Scientist Award. He attended 19th National Aerobiological Conference held at Bose Institute, Kolkata and won best oral presentation Award.

Miss Koyel SenGupta (SRF, Division of Plant Biology) working under Prof. Swati Gupta Bhattacharya attended 19th National Aerobiological Conference held at Bose Institute, Kolkata gave an oral presentation and won P.H. Gregory Memorial Award and medal.

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

Group Members :

Ms. Bijoya Karmkar and Ms. Koyel Sengupta (both SRF, Division of Plant Biology) working under Prof. Swati Gupta Bhattacharya attended the European Academy of Allergy and Clinical Immunology (EAACI) Annual Congress(June 11 – 15, 2016) at Vienna, Austria and presented poster and Poster Discussion Session (PDS).

Ms. Sangeeta Roy (SRF), Division of Plant Biology) working under Prof. Swati Gupta Bhattacharya attended The British Society for Allergy and Clinical Immunology (BSACI) Annual Meeting (September 29 – Octvober 1, 2016) at Telford, United Kingdom and presented a poster.

Ms. Debarati Dey (SRF), Division of Plant Biology) working under Prof. Swati Gupta Bhattacharya attended The British Society for Allergy and Clinical Immunology (BSACI) Annual Meeting (September 29 – Octvober 1, 2016) at Telford, United Kingdom and gave an oral presentation of her work.

The entire group members of Prof. Bhattacharyas' lab participated and volunteered for the organizing team of 19th NCIAS-2016 held at Bose Institute, Kolkata.

Grants-In-Aid Scheme:

Title of the Scheme	Schemes funded by
Study to understand the pollination ecology as well as the applicability of placing apiary boxes in the forested areas of The Sundarbans	WWF
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
With Dr. Sudipto Saha (Co-PI)	
Studies on mould spore diversity as environmental allergen in outdoor and indoor environments of urban and rural areas of Agartala, Tripura (upto June, 2017)	DBT
Diagnosis of mold allergy among inhabitants of urban and rural peoples of the Gangetic plane of West Bengal through aero-biological and immunochemical studies (upto November, 2017)	CSIR

Dr. Pallob Kundu

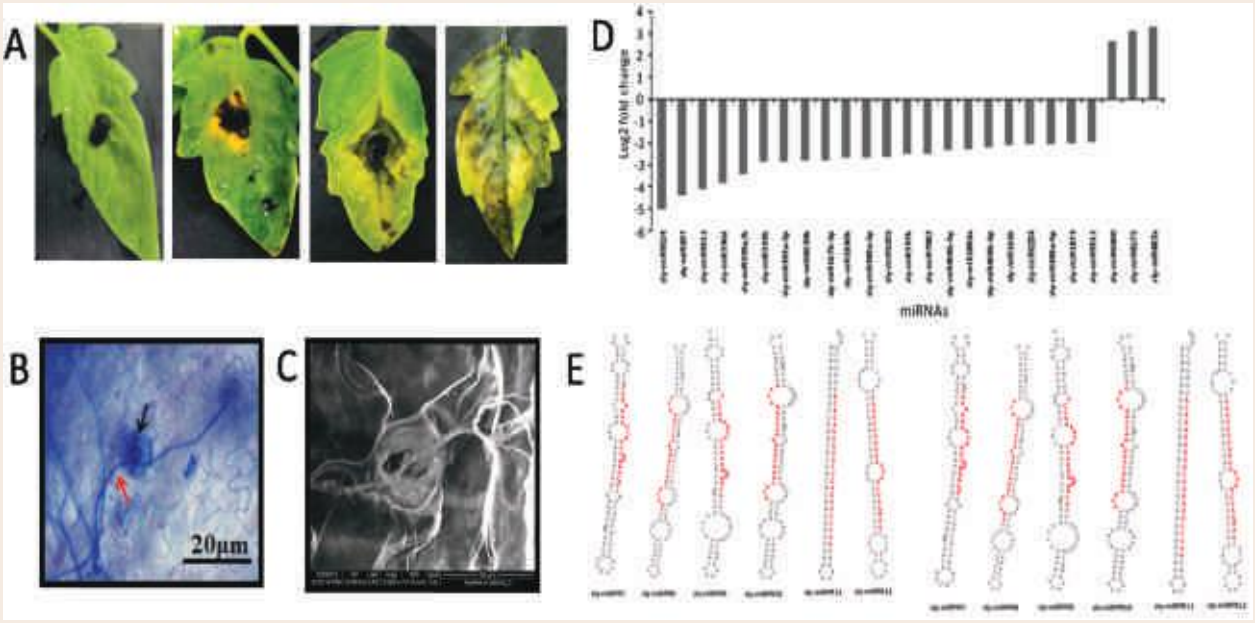
Associate Professor

Scientific Reports

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

In genome-wide analysis we have elucidated *Alternaria*-stress responsive miRNAs, mRNAs and miRNA-mRNA interacting pairs in tomato. By imposing very stringent selection criteria we have identified 102 miRNA-mRNA pairs which were regulated antagonistically. The candidate miRNAs identified from these studies are analyzed to gain insight into the mechanism of regulation of the miRNAs. We are analyzing the importance of (i) specific transcription factors in *MIR* gene expression,

(ii) RNA elements in miRNA processing and (iii) protein factors in stress-dependent expression of specific miRNAs. These analyses have revealed many crucial regulators, such as DREB, NAC transcription factors, of miRNAs during stress in tomato.



Early blight disease in tomato and miRNA expression. A, Early blight disease progression in inoculated leaves; *Alternaria* fungus hyphal invasion through stomata as seen in light (B), and scanning electron microscopic studies (C); D, highly differentially expressed miRNAs during infection; E, novel miRNA candidates detected in tomato cultivar Pusa Ruby. [DNA Research, March 3, 2017]

We have also found that five different miRNAs target ~ 37% of tomato NB-LRR genes. In depth analysis of some of these miRNA-NBLRR interactions has also been carried out. Our data confirmed specific miRNA-NBLRR interaction, and to gain further insight into the biological significance transgenic plants overexpressing the miRNA has been developed. This plant is being characterized and analyzed.

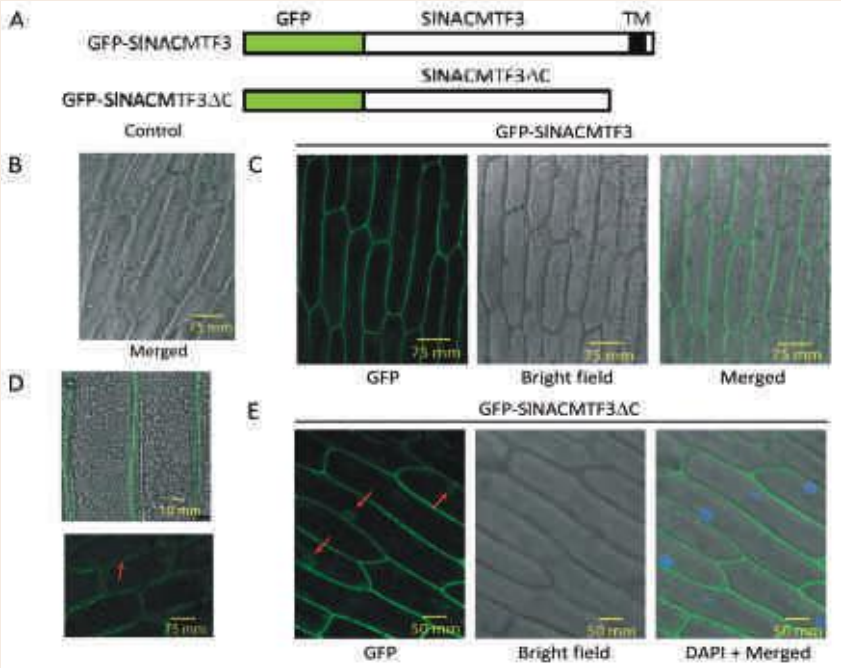
Thus, after revealing the key regulators of Alternaria-stress, we have focused on unraveling the exact biological significance of the miRNA-mediated regulation of specific genes and to understand the mechanism of regulation of the miRNA regulators during the stress. The knowledge gathered could be utilized 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

We have profiled tomato NAC transcription factors (NAC TF) and specifically the membrane bound NAC TFs (NAC MTFs). Detailed bioinformatic analysis based characterization of these MTFs has been completed. These NAC MTFs are also found to be stress responsive and two of these MTFs, namely SlNACMTF3 and SlNACMTF8, were selected for further in depth analysis. These MTFs were readily localized to the membrane, the transmembrane deleted version was found only in the nucleus, and caused differential regulation of expression of stress-related genes. The preferential binding site for SlNACMTF3 has been also elucidated. Genome-wide analysis has been undertaken to locate the promoters to which SlNACMTF3 would bind. Transgenic lines with reduced or over expression of the

MTFs are being generated to analyze the biological role of the identified MTFs.

Structure-function analysis of a novel membrane bound NAC transcription factor of tomato : *in collaboration with Dr. Supriyo Chowdhury, DBT-RA.*



Subcellular distribution of SINACMTF3. (A) Scheme of constructs. (B) Control merged image. (C) GFP-SINACMTF3 is localised specifically in membrane and (E) GFP-SINACMT3ΔC localised both in nucleus (red arrow) and cytoplasm. (D) Magnified image of GFP-SINACMTF3 and GFP-SINACMT3ΔC localization. [Plant Molecular Biology, 93(4-5):511-532, 2017]

Although the NAC-domain of all NAC transcription factors share similarities in structural features, they vary extensively in terms of their functionality including selection of a specific promoter. Suggesting, NAC adjacent sequences are important. Moreover, depending on the presence of the type of additional domains they can positively or negatively influence transcription. One of these NACs of tomato, namely SlNACMTF3, remain as dormant in its membrane bound form and transported to the nucleus when detached from membrane upon perception of specific stress signal. SlNACMTF3 has role in biotic stress signal transduction, the transmembrane domain of SlNACMTF3 suppresses its transcription regulatory function, and the transcription factor displayed differential binding efficiency to DNA sequences having altered NAC binding sites. Consequently, it has been found that SlNACMTF3 influenced regulation of several stress related genes. Investigations are in progress to find out the DNA sequence elements that are preferable interacting partner for SlNACMTF3, and protein motifs which are important for its transcriptional regulatory function. These studies will help in the identification of preferable NAC binding site of SlNACMTF3 and their location in chromosome, which ultimately would lead to the identification of key genes regulated by this factor.

Publications :

1. Bhattacharjee P, Das R, Mandal A, Kundu P (2017) Functional characterization of tomato membrane-bound NAC transcription factors, *Plant Molecular Biology*, 93(4-5):511-532. [Impact Factor: 3.9].
2. Mondal S, Bhattacharjee P, Sengupta P, Roychowdhury T, Saha P, Kundu P, and Chatterjee S (2017) Chelerythrine down regulates expression of VEGFA, BCL2 and KRAS by arresting G-Quadruplex structures at their promoter regions, *Scientific Reports*, 7:40706. [Impact Factor: 5.5]
3. Sarkar D, Maji R K, Dey S, Sarkar A, Ghosh Z, Kundu P (2017). Integrated miRNA and mRNA expression profiling reveals the response regulators of a susceptible tomato cultivar to early blight disease, *DNA Reserach*. [Impact Factor: 5.3]

Student awarded Ph.D. :

Name of Student (University/ Year)	Title of Thesis
Arunava Mandal (C.U., 2016)	Mechanism of Regulation of Leaf Developmental Gene(s) by Tomato Leaf Curl Virus in Infected Leaves

Grants-in-Aid Schemes

Title of the Scheme	Schemes funded by
As PI Exploring membrane-associated NAC-transcription factors (NAC MTFs) in tomato to apprehend membrane-mediated signaling during pathogenesis.	CSIR
As Co- PI, PI: Prof. D. N. SenGupta Functional analysis of the DNA polymerase lambda gene and the protein from indica rice cultivars.	DST, SERB
As Co-PI, PI: Prof. Amita Pal Genome wide transcriptome analysis to identify MYMIV-stress related genomic resources of Blackgram.	WB, DBT

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

(I) Delivered an invited lecture entitled "Identification of crucial miRNAs and dissecting their regulatory circuit during Alternaria-stress in tomato" in International symposium on "The green planet Past, Present and Future" organised by Department of Botany, University of Calcutta, 21 – 23 December, 2016 (ii) Delivered an invited lecture entitled "Integrated miRNA and mRNA transcriptomic reveals response regulators of Alternaria stress in tomato" in NHBT 2017 (New Horizons in Biotechnology) held on 17 – 18 February, 2017 at Haldia Institute of Technology, West Bengal; (iii) Delivered an invited lecture entitled "Integrated omics approach for identification of Alternaria-stress response regulators in tomato" in "Current Advances Molecular Host – Pathogen Interactions (Plants & Animals)" held on March 28 – 30, 2017 at NIT, Durgapur; (iv) Delivered an invited lecture on "Gene silencing: mechanisms and applications" for Ph.D. students at West Bengal State University, September 19, 2016; (v) Participated in organization of Third Bose Institute Alumni Association Convention, January, 2017, at Madhyamgram Experimental Farm Bose Institute; (vi) Member of the organizing committee of National Symposium on Transcription Assembly 2016, November 8 – 9, 2016 at Bose Institute, Kolkata; (vii) Served as a Joint Secretary in the organizing committee of International Symposium on "Insight to Plant biology in the Modern Era", February 8 – 10, 2017 held at Bose Institute as a part of the Centenary Celebration.

Group Members

Dr. Supriyo Chowdhury participated in the international conference "Insight to Plant Biology in the Modern Era" held in Bose Institute during February 8 – 10, 2017.

Deepti Sarkar, Jayanti Jodder, Sayani Dey, Payel Bhattacharjee, Rohit Das, Shreya Chowdhury, Shrabani Basak and Pallob Kundu presented on *Genome-scale analysis of miRNA-mRNA interactions during Alternaria infection in tomato*, International Symposium on "Insight to Plant biology in the Modern Era", February 8 – 10, 2017 held at Bose Institute, Kolkata.

Jayanti Jodder, Rohit Das, Deepti Sarkar, Payel Bhattacharjee and Pallob Kundu presented on Distinct transcriptional and processing activity regulate tomato mir167 biogenesis during stress, International Symposium on "Insight to Plant biology in the Modern Era", February 8 – 10, 2017 held at Bose Institute, Kolkata.

Payel Bhattacharjee, Rohit Das and Pallob Kundu presented on Identification and functional characterization of membrane bound nac transcription factors (SlNACMTFs) in tomato, International Symposium on "Insight to Plant biology in the Modern Era", February 8 – 10, 2017 held at Bose Institute, Kolkata.

Social relevance :

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

Dr. A. N. Lahiri Majumder

INSA Senior Scientist

Scientific Reports

Abiotic stress tolerance in plants: Regulation through Inositol and phosphoinositide metabolism

Functional promoter analysis of *INO1* promoters from a halophytic wild rice, *Porteresia coarctata* was done through bioinformatic analysis of *cis*-acting elements of *PcINO1.1* and *PcINO1.2* genes from *P. coarctata and their comparison made with OsINO1.1 and OsINO1.2 genes from O. sativa.* Presence and localization of abiotic stress responsive *cis* acting elements were demonstrated and were compared to those of *Oryza sativa*, pOsINO1.1 and pOsINO1.2. Deletion mutants for the above were generated followed by their molecular cloning to plant expression vector for transient expression and functional mapping of the promoters for each. MUG assay and qPCR analysis of the transiently transformed leaf discs of pPcINO1.2 deletion series indicated the presence of a 5'- 761 bp repressor region on deletion of which, pPcINO1.2.324 showed a sudden hike in reporter activity. This repressor region was cloned and factors responsible for the suppression were searched for in rice nuclear extracts which identified *trans* factors like retrotransposons and argonaute-like proteins which may act in post-transcriptional repression. Stable transgenics in Arabidopsis were generated for these and their expression levels under different stresses compared. Tissue specific expression specifically in the vascular bundles and meristematic zones was noted. Difference in tissue-specific reporter gene expression under different abiotic stresses are being validated by qPCR analysis.

Evolutionary analysis of the "core catalytic domain" of MIPS protein (coded by *INO1*) across different phyla has been done through bioinformatic studies. A conserved pentapeptide stretch containing the two essential Lys residues has been identified through *in vitro* mutagenesis and analysis of the expressed protein of the *OsINO1* gene.

Four isoforms of the Phosphoinositide-specific phospholipase C have been isolated from an *indica* rice . Sequence comparison of these genes with those of the *japonica* rice showed distinct differences between the two varieties. Expression pattern of the PLC genes under different stress conditions were done by RealTime analysis. Suitable constructs for plant introgression and functional expression for each gene have been made.

Publication :

1. Agarwal T, Upadhyaya G, Halder T, Mukherjee A, Majumder A L andRay S (2017) Different dehydrins perform separate functions in *Physcomitrella patens, Planta*, 245:101–118.

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

Delivered (i) Key Note address on "Antiquity and functional diversity of L-myo-inositol 1 phosphate synthase (MIPS)" in the 2nd National Seminar on "Current trends in Life Science" organized by the South Central University at Patna during February 20 – 21, 2017; (ii) an invited talk in the One-day seminar on "Public understanding of Science" organized by NASI & ISNA at Kolkata on February 24, 2017; (iii) Inaugural address in the International Conference on "Green Planet" in February, 2017 organized by the Department of Botany, Calcutta University; (iv) Chaired sessions at the PTCA meeting at Calcutta in February, 2017. (v) Visited As an Exchange visitor through INSA and National Academy of Science and Technology (NAST) of the Philippines, visited the International Rice Research Institute (IRRI), Las Banos, Manila during December 01 – 12, 2017. Also delivered a number of talks at IRRI and interacted with the scientists.

Honours/ Awards :

(i) As a member of the Editorial Board, presently serving as the Editor of the Plant Sciences section of the PINSA, Proceedings of the Indian National Science Academy; (ii)Serving as an Editorial Collaborator of the Science & Culture , of Indian Science News Association, Kolkata.

Grants –In-Aid Schemes :

Title of the Scheme	Schemes funded by
With Dr Shubho Chaudhuri (as Co-PI) *Co-PI- Overseas Collaborator : Dr Teun Munnik, Netherlands* Unraveling the role of PLC in plant drought and heat tolerance : Exploring the potential of PI metabolism to improve crop yield.	DBT-NWO India-Netherlands collaborative project
Inositol and phosphoinositide metabolism in relation to plant abiotic stress tolerance	INSA Senior Scientist project

(*With Dr Rajeswari Mukherjee as PI*)

An approach towards gene mining and bioprospecting of Mangrove genepool : special reference to *Porteresia* and/or *Salicornia*	DBT Bio-CARe programme\

(With Dr Priyanka Das as PI)

Analysis of salt tolerance in grapevine through transciptomic and proteomic approach, and functional validation of key genes responsible for salinity tolerance in transgenic *Arabidopsis thaliana*	SERB Young Scientist Project

Dr. Amita Pal

CSIR-Emerius Scientist

Scientific Reports

Genome wide transcriptome analysis to identify immune responsive genes in resistant, MYMIV-challenged *Vigna mungo*

We had undertaken a project to understand molecular mechanism of resistance in*Vigna mungo* against Mungbean Yellow Mosaic India virus (MYMIV) through genomic and proteomic approach. In continuation of that here we report genome-wide transcriptome profiles of *V. mungo* during incompatible interactions between *V. mungo* and MYMIV. IlluminaHiSeq 2000 platform and various bioinformatics tools were used for *de novo* assembly. Homologous transcripts were identified and the highest homology was noted with *V. radiata* followed by *Solanum tuberosum*, *V. angularis* and *S. pennellii.* Over-expressed genes encoded biotic stress associated proteins such as chlorophyll a/b binding protein, ATP synthase, serine hydroxymethyl transferase, catalase, superoxide dismutase (Cu-Zn), heat-shock protein etc, which are implicated in host immune response were identified. Among different gene ontology (GO) categories, 1131 GO IDs were assigned to biological processes, 277 to cellular components and 993 to molecular functions in samples after MYMIV-inoculation (MI). Differential expression of transcription factors was analyzed to reveal the essential regulatory modules that are over-expressed during incompatible interaction. 338 MI-transcripts out of 14750 were found to be involved specifically in plant-pathogen interaction when mapped to KEGG pathways; these include transcription factors, CDPK, MAPKK1, MAPK1/3 and serine/threonine-protein kinase PBS1. This is the first transcription profiling of the non-model *V. mungo* under MYMIV-stress and mock-control. Basic helix loop helix class was the most abundant transcription factor in *V. mungo*.

Elucidating the role of *Vigna mungo* MAPK (VmMAPK1) in restricting MYMIV multiplication: *in collaboration with Dr. Shubho Chaudhuri*

In the previous year we had isolated *VmMAPK1* (GenBank ID KF318321) from a resistant inbred line of *V. mungo*. *VmMAPK1* showed induced expression in the resistant background upon MYMIV

inoculation and based on circumstantial evidences considered as one of the key players in the early signaling pathway. Abundance of the target protein in MYMIV-inoculated *V. mungo* was noted and confirmed by immune-blotting the total protein using 21 amino acids of C terminal peptide of VmMAPK1-specific polyclonal antibody. Participation of VmMAPK1 in MYMIV defense pathway was shown by over-expressing VmMAPK1 in the heterologous tobacco plant that restricts virus accumulation. In transgenic tobacco plants expression of the PR1 and PR5 were significantly higher than that of the wild tobacco plants, suggesting VmMAPK1 activation regulates the expression of pathogenesis responsive genes. Taken together we conclude that over-expression of *VmMAPK1* can cause inhibition of viral replication thereby restrict the accumulation of the virus in the host plant.

Publications :

1. Biswas P, Chakraborty S, Dutta S, Pal A, Das M (2016) Bamboo flowering from the perspective of comparative genomics and transcriptomics. Perspective, Front. Plant Sci. 7:1900.doi: 10.3389/fpls. 2016.01900
2. Ghosh J S, Bhattacharya S and Pal A (2017) Molecular phylogeny of 21 tropical bamboo species reconstructed by integrating non-coding internal transcribed spacer (ITS1 and 2) sequences and their consensus secondary structure. 145:312-333, DOI: 10.1007/s10709-017-9967-9
3. Kundu A, Paul S, Dey A and Pal A (2017) High throughput sequencing reveals modulation of microRNAs in *Vigna mungo* upon *Mungbean Yellow Mosaic India Virus* inoculation highlighting stress regulation. Plant Science 257: 96–105, DOI:10.1016/j.plantsci.2017.01.016
4. Kundu A, Paul S, Pal A and Genotypic Technology (2016) Mungbean Yellow Mosaic India Virus (MYMIV)-infection, Small RNA Library Construction and Deep Sequencing for MicroRNA Identification in *Vigna mungo*. Bioprotocol Vol 6, Issue 20, DOI: http://dx.doi.org/10.21769/BioProtoc.1961
5. Paul S and Pal A (2017) Genome-wide Characterization of MicroRNAs from Mungbean (*Vigna radiata* L.) Biotechnology Journal International 17(1): 1-9, DOI: 10.9734/BJI/2017/30984

Grants-in-aid-schemes :

Title of the Scheme	Scheme funded by
With Dr. Malay, PI and Dr. Amita Pal, Co-PI Identification and functional characterization of genes regulating unique flowering behavior in tree bamboo.	CSIR
Dr. Amita Pal, PI Genomewide transcriptome analysis to develop strategies for quality improvement of blackgram.	DBT (W B) project
Dr. Amita Pal, PI 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 :

(I) Delivered 13th J. C. Sengupta endowment lecture entitled "An integrated approach to understand plant defense strategy against yellow mosaic disease of a legume plant" on 27 May, 2017, organized by the West Bengal Association of Science and Technology, Kolkata (ii) Participated in a one day Symposium on "The world of microbes: Pathogenesis, Environment and Evolution, organized by the Department of Microbiology, Bose Institute as a part of Centenary Celebration, held on 17 October, 2016 (iii) Delivered an invited talk on "Functional genomics approach to understand immune response of *Vigna mungo* against MYMIV" in the International Conference on The Green Planet: Past, Present and Future, organized by the CAS Phase VII, Department of Botany, University of Calcutta, Kolkata from 21 – 23 December, 2016 (iv) Co-chaired the first Technical session of the International Symposium on "Insight to Plant Biology: In the Modern Era" organized by the Division of Plant Biology, Bose Institute from 8 – 10 February, 2017 (v) Posters presented by Sayak Ganguli, Sambhasan Biswas, Pankaj K Singh and Amita Pal on "Analyses of *Vigna mungo* differential transcriptomes during incompatible interaction with MYMIV using an efficient GUI tool, the DB-COMPARATOR" in the International Symposium on "Insight to Plant Biology: In the Modern Era" organized by the Division of Plant Biology, Bose Institute from 8 – 10 February, 2017 vii) Chaired the Second Scientific Session in the National Symposium on Plant Biotechnology: Current Perspectives on Medicinal and Crop Plants, organized by IICB, held in Kolkata on 3 – 5 March, 2017 (viii) Following Posters were presented in the National Symposium on Plant Biotechnology: Current Perspectives on Medicinal and Crop Plants, organized by IICB, held in Kolkata on 3 – 5 March, 2017.

Group Members :

1. "Identification of immune responsive genes in MYMIV-resistant *Vigna mungo*" presented by Pankaj Kumar Singh, Avishek Dey, Sayak Ganguli, and Amita Pal.
2. Pankaj Kumar Singh orally presented the paper on "Identification of immune responsive genes in MYMIV-resistant *Vigna mungo*"
3. "Identification and molecular characterization of *CO-FT* co-regulon in a rarely flowering tree *Bambusa tulda*" by Prasun Biswas, Smritikana Dutta, Amita Pal and Malay Das.
4. "Identification and characterization of genes regulating unusually long flowering time in bamboo by targeted and non-targeted methods" by Sukanya Chakraborty, Amita Pal and Malay Das.

Awards and Honours received :

- Received S.C. Dutta memorial award from the Botanical Society of Bengal for the year 2016.
- Elected to deliver the 13th J. C. Sengupta endowment lecture on 27 May, 2016, organized by the West Bengal Association of Science and Technology, Kolkata.

Dr. Dibyendu Narayan Sengupta

Honarary Scientist

Scientific Reports

Regulation of Gene Expression in indica rice cultivars DNA Pol λ and analysis of the several lines of IR-64 rice transformed to overexpress the cDNAs for rice SamDc and rice OsBZ8, a transcription factor

In our DST-SERB financed project on DNA Pol λ, a 68 kD protein with N-terminal BRCT domain responsive to protein-protein interaction, a serine-proline domain and a C-terminal DNA Pol β domain having DNA polymerization activity sensitive to ddNTP, we were able to amplify the 3' 1097 bp region containing the C-terminal 42 kD β domain part. The cDNA was over-expressed in *E. coli* as His tagged fusion protein using pET28a vector system. The protein after extensive purification to single band, was found to have activity like DNA Pol β, sensitive to ddNTPs. Total RNA isolated from IR-29 (salt sensitive), Nonabokra (Salt-tolerant) and N-22 (dehydration tolerant) cultivars of control and NaCl treated plants which showed the upregulation of DNA Pol λ transcripts (+/- 1.6 kbp). Now, we are trying to amplify the full length ORF of DNA Pol λ using newly design primers from 5' and 3' ends of the ORF. The protein of DNA Pol λ was partially purified from plant tissues after different stress treatments like Salt, Dehydration, Heat and cold and also from tissues of different stages of plant growth and were subjected to polymerase activity assay and western blot analysis. Results showed higher expression of DNA Pol λ in IR-29 than Nonabokra and N-22 against different stresses and higher expression was observed during early stages of germination and also during initial stages of flower development. Experiments are going on to detect the sequence of 5' unknown region containing the BRCT domain to study its association with other proteins involved in DNA damage repair.

We started to over-express rice SamDc and OsBZ8 separately in IR-64 rice through *Agrobacterium* (with pCAMBIA containing hygromycin marker gene and either SamDC or OsBZ8 cDNAs from rice under 35S promoter) mediated gene transfer (DBT,GOI sanctioned sub project III project from 5.10.2010 to 4.10.2015). So far we have many different transgenic T3 generation plants for SamDc over-expressed line. We have started to characterize those transgenic lines and Hygromycin (50 µg/ml) resistance were observed in many different regenerated plants. Plants were grown in Greenhouse separately at MEF, BI. Genomic DNAs were made and considered for Southern Blot analysis. Success in the analysis showed the presence of the transgene in many of them. Northern blot analysis also done with few of these transgenic lines and showed the enhancement in the expression as compared to untransformed rice. RT-PCR experiments with fusion primer (35S with SamDC2 from the 5' end and a another primer from SamDC2 cDNA was able to amplify the transcripts from the transgene (s). Western blot analysis with the polyclonal antibodies made against rice SamDC protein (developed in our lab) was done and now we are planning for the estimation of polyamines like spermidine (Spd,3+) and spermine (Spm,4+), as they will be produced by the over-expressed SamDC from the transgene (under the 35S promoter). High level of Spd is known to protect the plasmamembrane affected by salinity or dehydration stress.

Similarly in our DBT,GOI project (2010 to 2015) another mandate for us was to produce transgenic plants over-expressing cDNA for OsBZ8 with Hygromycin resistant marker gene under the control of 35S constitutive promoter in pCAMBIA 1301 by using Agrobacterium tumifaciens LBA4404. Mr. Tathagata Nath , a CSIR-NET fellow, is working on this project. So far we have 10 different lines of T2 transgenic plants (Hygromycin tolerant as they germinate on MS medium containing hygromycin at 50 ug/ml). Genomic DNAs were prepared and used in Southern blot analysis. In addition, genomic PCR with the special fusion primer 35S:OsBZ8 (present in the T-DNA) and OsBZ8 3' primer have shown the amplification of 35S:OsBZ8. We are trying to get clear picture from Southern Blot and northern blots. In the meantime, new genomic DNA from T2 samples are now under preparation. In addition the ABA level in roots and shoots of control and salt treated IR-29, IR-64,Pokkali and Nonabokra have been quantified from the HPLC generated data and also the expression of the genes for ABA anabolism (ZEP, NCED, & AAO) and catabolism (ABA 8 hydroxylase) were measured. Level of Cations (Na^{+},K^{+},Ca^{2+}, and Mg^{2+}) also measured by Atomic Absorption Spectrophotometer and important differences were observed.

Last year we have reported on our cloning and characterization on 14-3-3f and g cDNAs and this year we have done northern blot analysis and found enhancement of the transcripts after salinity stress or dehydration. Real Time PCR was done and enhancement was noticed in both cases. Western blot analysis was done using 14-3-3f antibody (generated from E.crli expressed rice 14-3-3f in our lab) in different rice cultivars during abiotic stress and in different developmental stages of rice plants. The interaction of 14-3-3f with other protein in normal untransformed indica rice plants and the role of SnRK with polyamine biosynthesis will be studied to find out the role in the transgenic rice plants.

Dr. Swati Sen Mandi

ICMR-Emeritus Medical Scientist associated with DPB

Scientific Reports

Withania somnifera:

Withania somnifera (Aswagandha), is often referred to as "Indian ginseng" because of its rejuvenating effect on patients with wide ranging ailments, such as senile dementia, diabetes, emaciation, insomnia, Parkinson's disease, nervous disorders, impotency, epilepsy, leprosy, rheumatism, arthritis, intestinal infections, ulcers, bronchitis, asthma, cold and coughs, conjunctivitis, and a suppressant in HIV/AIDS. This plant has also been widely used in treatment of various types of carcinoma. As there are many varieties of *Withania somnifera* available in India, there is a need for evaluating available varieties with respect to Withaferin-A; selecting the superior variety with high content of this active principle would be of use to pharmaceutical industries.

Our studies demonstrated a varietal difference in content of Withaferin-A among some varieties of *Withania somnifera*, collected from CIMAP, Lucknow. HPLC analysis revealed that the variety

Chetak contains highest amount of Withaferin-A (30.09 μg/g) whereas variety Poshita contain lowest amount (14.09μg/g). The other varieties contain intermediate amounts of this compound such as Pudina(18,76 μg/g), Pratap(20.45 μg/g) and Nimtli-118(22.02 μg/g). AFLP analysis of these varieties using six pairs of primers has been undertaken for identity establishment of these varieties of *Withania somnifera*. Multiple Regression Analysis (MRA) correlating active principal content (Figure 1a) with genomic profile (AFLP pattern) (Figure-1b) identified a 203 bp allele (generated by primer pair EcoRI-AAC / MseI-CTT) as trait (Withaferin-A) related AFLP Marker in *Withania somnifera.* This marker for Withaferin-A would be useful for screening wild germplasms for selection of elite genotype containing high amount of Withaferin-A. Such information as well as DNA fingerprinting based assessment of starting material for use in production of pharmaceuticals would be useful to the industry.

Stevia rebaudiana:

Stevia rebaudiana is a tender perennial herb native to parts of Brazil and Paraguay. Despite being an exotic species (native to Brazil, Venezuela, Colombia and Paraguay), this plant has established successfully under Indian ecosystems. It is widely cultivated in different parts of India, particularly because of its commercial value as a natural sweetener and also because of its medicinal potential in treatment of diabetes and pancreatic cancer. *Stevia rebaudiana* leaves are estimated to be 300 times sweeter than sucrose and the sweetness is due to glycosides of which the most abundant is stevioside. As for all medicinal plants, this plant (with high commercial and medicinal value) also calls for development of AFLP genome analysis based Species Specific Marker(s) for authentic identification in avoiding adulterant related problems of vendor collected plants, often faced by pharmaceutical companies.

For our study *Stevia rebaudiana* plants were collected from a wide range of locations including Himachal Pradesh, Punjab, Lucknow, Varanasi, and Kolkata. AFLP analysis of genomes in these ecotypes was performed for exploring genetic diversity; in this study 6 primer pairs were used. Representative AFLP pattern of *Stevia rebaudiana* species is given in Figure-2b. Phylogenetic tree obtained after analysis of AFLP derived binary matrix revealed that plants collected from a particular location exhibit high genetic similarity (Figure-2a). Plants from each location appeared clustered

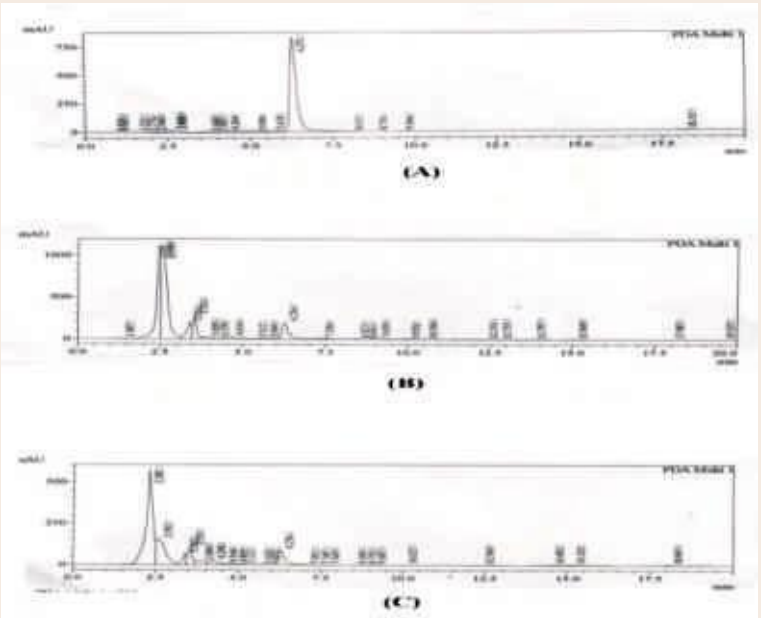


Figure 1a. Representative HPLC Chromartogram showing variation in Withaferin – A content in different varieties of *Withania somnifera* (Retention time : 6.2 min) (A) - HPLc Standard (Sigma-Aldrich), (B) - HPLC Chromatogram of Chetak variety showing hishest content and © - HPLC Chromatogram of Poshita variety showing lowest content. (X-axis – Time, Y-axis – mAU),

together. whereas plants from different location clustered separately. In spite of these variations at infraspecific level, some alleles that are found to be present in all ecotypes regardless of their place of collection represent Species Specific markers for *Stevia rebaudiana*. Such marker(s) will be helpful for authentication of this plant for ensuring uniform efficacy in medicine produced in each batch.

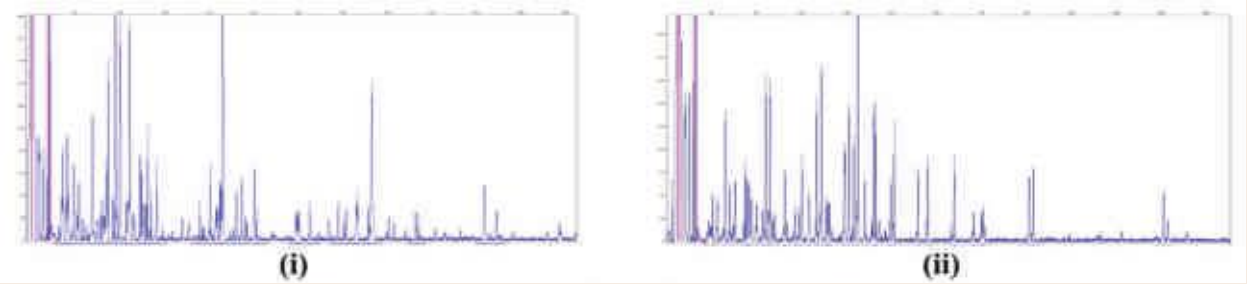


Figure 1b. Representative AFLP chromatogram of two varieties of *Withania somnifera* using the primer pair EcoRI-ACG

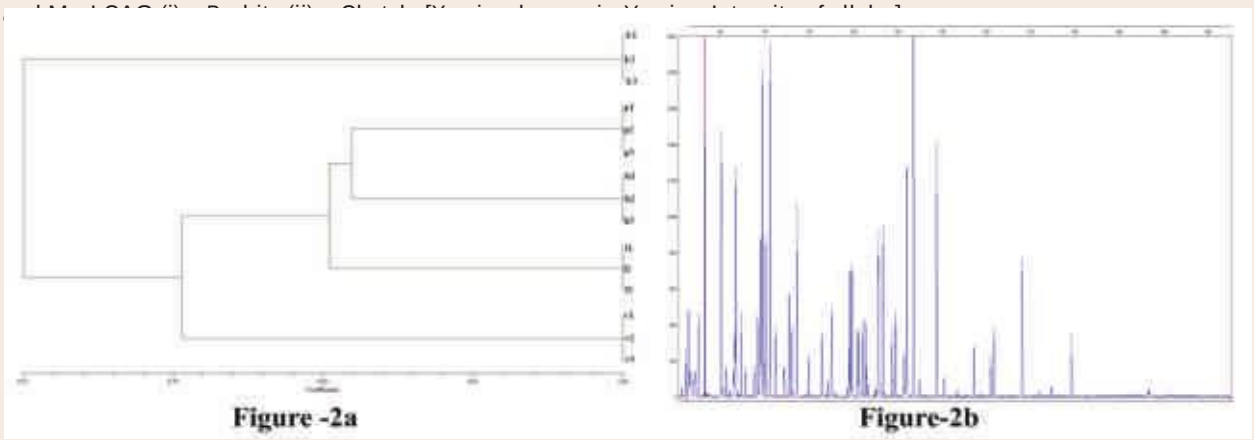


Figure-2a. AFLP based dendogram of *Stevia rebaudiana* showing clustering of genotypes in association with their place of collection (k1,k2,k3- colected from Kolkata, v1, v2, v3 – collected from Varanasi, p1, p2, p3 – collected from Punjab, h1,h2,h3 – collected from Himachal Pradesh and I1, I2, I3- collected from Lucknow.

Figure-2b. Representative Electropherogram showing AFLP fingerprinting patterns of Stevia rebaudiana collected from Punjab using primer pair *Eco*RI-ACG and *Mse*I-CTG. [X-axis = base pair of alleles ; Y-axis = intensity of allele].

Dendrobium thyrsiflorum

Orchids, an important group of medicinal plants, represent the largest and most genetically diverse groups amongst the angiosperms. In recent years, due to heavy rate of deforestation and other anthropogenic pressures the natural populations of many splendid orchids are depleting fast from their natural habitats at an alarming rate and their conservation is becoming a matter of global concern. Knowledge of genetic diversity provides a significant insight into the population dynamics and fitness of a species and therefore is of utmost importance for designing conservation strategies. In rare, endangered and threatened (RET) category plants, knowledge of genetic diversity is extremely important as loss of genetic diversity directly reduces survival chances in the wild and subsequently leads to the extinction of the species.

A threatened medicinal orchid, *Dendrobium thyrsiflorum* that has been reported to be effective in treatment of various chronic disorders has been taken up in our study. Collections of *Dendrobium thyrsiflorum* were made from a wide range of locations in NE India including five states viz. Meghalaya, Mizoram, Arunachal Pradesh, Sikkim and Manipur.

A total of nine pairs of selective primers were used in AFLP fingerprinting of genomic DNA extracted from five sampled populations of *D. thyrsiflorum.* A total of 1207 peaks were obtained of which only 19 peaks were monomorphic and the rest 1188 were polymorphic; thus 98.5% polymorphism is detected. Along with significant levels of DNA polymorphism, the estimated Nei's gene diversity value of 0.28 re-confirms high genetic diversity level within the sampled *D. thyrsiflorum* populations. Apart from providing a useful tool for germplasm identification and genetic diversity, these AFLP markers will be very useful in genetic mapping and assistance in early progeny selection and conservation as well as sustainable commercial utilization of this medicinally important orchid species.

Publications :

1. Bhattacharyya P, Ghosh S, Mandi S Sen, Kumaria S, Tandon P (2017) Study on Genetic Diversity by Amplified Fragment Length Polymorphism analysis in *Dendrobium thyrsiflorum*, a threatened medicinal orchid, *South African Journal of Botany* 109: 214-222.
2. Mandi S Sen (2016) Natural UV Radiation in Enhancing Survival value and Quality of Plants. Springer Publication.

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

Delivered Invited Lecture in an International Conference on Global Biodiversity and Climate Change from October 15 – 18, 2016 at Rajiv Gandhi University, Arunachal Pradesh, India.

Social Relevance :

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

In addition to conducting state-of-art research in authentication and evaluation of medicinal potential through genetic, biochemical and chemical analysis together with bioprospecting of medicinally important genes, this programme routinely provides Hands-on-Training to young researchers countrywide with particular focus on North East India with an aim to Transferring Technology appropriately to laboratories of participating scientists.

Dr. Samir R. Sikdar

Senior Professor & Coordinator

Scientific Reports

Exploring *Brassica juncea* cultivars for aphid tolerance and development of transgenic *B. juncea*cv. B-85 with over expression of RiD

Aphid tolerance level among 10 *Brassica juncea* cultivars from different agro-climatic zones of India was performed in the backdrop of wild crucifer *Rorippaindica*, in field conditions against mustard aphid *Lipaphiserysimi* (2016-2017). In this experiment, we have studied the phenotypic variations and a weather based aphid population among those cultivars. We found cv. Ashirwad (RK-01-03) as the most tolerant and cv. PusaMahak (JD-6) as the most susceptible *Brassica* lines.

The EST which was found to be highly up-regulated in *Rorippaindica*on aphid infestation was*Rorippaindica* defensin (RiD). After artificial diet based insect bioassay and biosafety assessmentsRiD is found to be a significant insecticidal agent against *L. erysimi*and a safe candidate for transgenic mustard development.The susceptible *B. juncea*cv. B-85 was transformed with the full length, coding sequence of RiDusing *Agrobacterium*-mediated plant transformation method. The PCR positive transgenic plants were analyzed for single copy transgene insertion through Southern blot analysis. The segregation of the transgene in T_1 generation was analysed using χ^2 test and there was no significant difference between the observed and expected Mendelian ratio (3:1). Western blot analysis confirmed the expression of RiD in the five T_1 transgenic plants corresponding to the T_0 lines.Quantitative expression of RiD in the T_1 transgenic lines was monitored using ELISA. The expression level of RiD in different transformants varied from 0.27 % to 0.86 % of total soluble protein. Immunohistochemical analysis was also conducted to visualize the expression of RiD in the T_1 plant tissues. RiD was seen to be strongly expressed in all the tissues indicating its presence in leaves, stem as well as roots. Finally,*in planta* bioassay results clearly indicated that constitutive expression of RiD in transgenic plants reduces the insect population significantly varying from 46.67 – 66.67 %. The fecundity of aphids in RiD expressing transgenic plants was seen to vary between 18 – 45 % compared to the control plants.

Fruit body production and, morphological and molecular characterization of inter-generic somatic hybrid strains produced between *Pleurotus florida* and *Agaricus bisporus*

Six inter-generic somatic hybrids (*PfAb1-PfAb6*) produced earlier through polyethylene glycol (PEG)-mediated protoplast fusion between two edible mushroom strains *Pleurotusflorida* and *Agaricusbisporus* were analysed through comparative study of colony morphology, mycelial growth, hyphal traits, inter single sequence repeat (ISSR) marker profiling and RFLP profiling of rDNA-ITS region. Out of 9 ISSR primers used, 6 primers showed good polymorphism with a total of 71 scorable fragments which ranged between 200-2500 bp in size and 79.56% polymorphism. Some of the ISSR bands of the fusant lines resembled to the parental bands and some were new non-parental bands. Fruit body has been produced from 2 *hybrid strains (PfAb 1* and *PfAb 4*) which morphologically resembled to *Pleurotusfloridaparent.*

Publications :

1. Ghosh S and Sikdar S (2016) Evaluation of protein extraction protocols and efficient solubilization for enhanced proteomic analysis from phenolics rich non-model recalcitrant wild crucifer *Rorippaindica* (L). Hiern. *Journal of proteins and proteomics* 7(4) 311-321.
2. Mallik P, Ghosh S, Chattaraj S and Sikdar S (2016) Isolation of mesophyll protoplast from Indian Mulberry (*Morus alba* L) CV. S1635. *Journal of Environment and Sociobiology* 13(2).
3. Sarkar P, Jana J, Chatterjee S and Sikdar SR (2016) Functional characterization of *Rorippaindica* defensin and its efficacy against *Lipaphiserysimi*. Springer Plus: 511 doi: 10.1186/s40064-016- 2144-2.

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

(i) Delivered aninvited talk on "Translation of existing knowledge through Scheduled Tribe-Specific Rural Biotechnology Programme for development of rural economy of India" in the International Symposium on Translational Research held on April 4, 2016 at Bose Institute, Kolkata; (ii) Delivered a talk on “Prospect of Sericulture in socio-economic development of tribal areas of West Bengal” in the UGC sponsored National Level Seminar on “Socio-Economic Impact of Integrated Disease Management in Sericulture in the Tribal Villages of West Bengal” organised by The Department of Agriculture & Rural Development, Sociology & Political Sciences, ChandraketugarhSahidullah Smriti Mahavidyalaya, Berachampa, North 24 Parganas in collaboration with Bose Institute, Kolkata during 1 – 2 September, 2016; (iii) Delivered a talk on “Constraints and Remedies Towards Rural Development: A Bose Institute Initiative” at Kanchrapara College, Kanchrapara, North 24 Parganas on March 01, 2017; (iv) Delivered a talk on “*Rorippaindica* defensin: a biologically safe novel peptide enhances aphid tolerance in *Brassica juncea” in the*UGC-SAP National Seminar, 2017 on “Perspective of Phytoresources and its Sustainable Utilization” held during 9 – 10 March 2017 in the Department of Botany, Tripura University, Suryamaninagar, Tripura 799 022; (v) Delivered a talk on “Biotechnological approaches for improvement of economically important mushrooms” in a one day seminar on 16.03.2017 under UGC-SAP - DRS 1 Scheme on "Enterprising Mushroom Biotechnology for Food Feed and Biomanure" organized by Department of Plant Pathology, Tamil Nadu Agricultural University, Coimbatore - 641 003, Tamil Nadu; (vi) Act as Session Chair & Judge for the Technical Session on Life Sciences-Botany in the Regional Science & Technology Congress at NITTTR, Salt Lake, Kolkata on 13 – 14 November, 2016 organised by Department of Science & Technology, Government of West Bengal; (vii) Organised as Joint Organising Secretary, the International Symposium on “Insight to Plant Biology: In the Modern Era” organized by the Division of Plant Biology, Bose Institute from 8 – 10 February, 2017.

Group Members :

Poulami Sarkar attended and presented a poster entitled “Expression of *Rorippaindica* defensin in *Brassica juncea* enhances tolerance against *Lipaphiserysimi*” in the XXV International Congress of Entomology, during September 25 – 30, 2016 held in Orlando, USA.

Presented following posters in the International Symposium on "Insight to Plant Biology: In the Modern Era" organized by the Division of Plant Biology, Bose Institute on February 8 – 10, 2017.

i. "Inter-generic somatic hybrid production between *Pleurotusflorida* and *Agaricusbisporus* and their molecular characterization" presented by Shruti Chattaraj and S.R. Sikdar.

ii. "Morphological and molecular characterization of 12 cultivars of Orchid (*Vanda*spp)" presented by Sourav Bose, Gaurab Gangopadhyay and S. R. Sikdar.

iii. "Standardisation of in vitro adventitious shoot organogenesis in sesame (*Sesamumindicum* L.) cultivar JK-1 and the associated role of abscisic acid in organogenesis" presented by Anirban Jyoti Debnath, Gaurab Gangopadhyay, DebabrataBasu and S. R. Sikdar.

iv. "Identification for defence related proteins from wild crucifer *Rorippaindica* (L.) Hiern against mustard aphid *Lipaphiserysimi* (Kaltenbach)" presented by Sayantan Ghosh and S. R. Sikdar.

v. "Jasmonate responsive gene, *Rorippaindica* defensin promotes *Lipaphiserysimi* tolerance in *Rorippaindica* by binding to its midgut α-amylase" presented by Poulami Sarkar, Madhushri Mitra and S. R. Sikdar.

Presented poster entitled "Isolation and characterization of HSPRO2 a defence gene from *Rorippaindica* (L.) Hiern, a wild relative of cultivated crucifers" by Sourav Bose and S.R. Sikdar in the National Symposium on "Plant Biotechnology: Current Perspectives on Medicinal and Crop Plants"and 38th Annual Meeting of Plant Tissue Culture Association organized by IICB, held in Kolkata on 3 – 5 March, 2017.


International Symposium

SCIENTIFIC REPORTS

II

Structural Studies and Biophysical Problems

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

Gautam Basu (Coordinator), Dr. Pinakpani Chakrabarti, Dr. Pradeep Parrack, Dr. R. Chattopadhyaya, Dr. Jayanta Mukhopadhyay, Dr. Anirban Bhunia, Dr. K. P. Das, 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

Senior Professor and Co-ordinator

Scientific Reports

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

We had previously crystallized GluRS from *E. coli* but due to poorly diffracting crystals, the structure could not solved. Towards deciphering the structure of GluRS, we have attempted to crystallized *E. coli* GluRS in presence of $tRNA^{Glu}$, ATP and Glu. In addition, we have also cloned, expressed and purified GluRS from the thermophilic bacterium *Methylacidiphilum fumari*olicum. The protein could be crystallized but the quality of the crystals was not good. Further crystallization attempts are in progress.

Backbone-sidechain concerted motion in designed peptides: *in collaboration with Prof. S. K. Pal, SNBNCBS, Kolkata*

Polypeptide dynamics play a key role in protein function during which both the backbone and the sidechains move in a concerted fashion. Although such concerted dynamics have been observed in computer simulations, direct experimental observations are rare. By monitoring the time resolved Trp fluorescence in a designed peptide (Ac-Ala-Pro-Trp-NH2) after a LiCl solvent jump, we have been able to directly observed backboen (omega angle of Pro) and sidechain (chi1 angle of Trp), by fitting the data to an appropriate model.

Biophysical studies on crenactin polymerization: *in collaboration with Dr. Abhrajyoti Ghosh*

Crenactin, an actin analog found in some archeal species, is a relatively recent discovery. The polymerization behavior of crenactin is not so clearly established as actin. We have successfully cloned, expressed and purified an actin mutant with a designed cysteine residue and have successfully incorporated a pyrene chromophore at the site. Polymerization studies are going on using Pyrene fluorescence, with the aim to decipher unique properties of crenactin polymerization, not associated with actin.

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

Small molecules often bind dsDNA that enhances their fluorescence. Such molecules can act as excellent bio-probes. Two psuch probes — AT-specific hemicyanine-based thiazole coumarin (TC) and quinone cyanine–dithiazole (QCy–DT) based switch-on probes, red and near-IR fluorescent, respectively — have been recently reported for DNA recognition by T. Govindraju at JNCSAR, Bangalore. We have probed the interactions of TC and QCy-DT with a short dodecameric self-complementary sequence D1 (5'-CGCGAATTCGCG-3') using ^{1}H NMR spectroscopy. The aim of the study is to identify specific interactions with DNA and determine the DNA-binding modes.

Publication:

1. Mahata T, Kanungo A, Ganguly S, Modugula E K, Choudhury S, Pal S K, Basu G, Dutta S (2016) The Benzyl Moiety in a Quinoxaline-Based Scaffold Acts as a DNA Intercalation Switch. *Angew Chem Int Ed Engl.* 55:7733-7736. IF: 11.709

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

Delivered invited lecture on (i) Direct observation of concerted backbone-side chain dynamics in short Linear Peptides at the Third International Symposium on Protein Folding and Dynamics, NCBS, Bangalore, November 8 – 11, 2016; (ii) Protein Structure and Dynamics Specific to cis-Proline at the Annual Symposium of the Indian Biophysical Society held at IISER Mohali during March 23 – 25, 2017.

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.

Patent :

Dr. Anirban Bhunia and Dr. Santasabuj Das. PCT International Patent No.: PCT/IN2016/000040 (Publication No.: WO2016132377 A1)

Award and Honors received :

Dr. Bhunia was recipient of the "National Magnetic Resonance Society (NMRS) – Prof. S. Subramanian's 60th Birthday Award" lecture for the year 2016 because of the exceptional contribution to the field of Magnetic Resonance and its applications.

Selected Publications :

1. Datta A, Yadav Y, Ghosh A, Choi J, Bhattacharyya D, Kar RK, Ilyas H, Dutta A, An E, Mukhopadhyay J, Lee DK, Sanyal K, Ramamoorthy A, Bhunia A (2016) Mode of Action of A Designed Antimicrobial Peptide : High Efficiency in Killing the Human Fungal Pathogen Cryptococcus neoformans. *Biophysical Journal* 111, 1724-1737.
2. Ghosh A, Pradhan N, Bera S, Datta A, Krishnamoorthy J, Jana NR, 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 Neurosc.* 8, 718-722.
3. Ratha B N, Ghosh A, Brender J R, Gayen N, Ilyas H, Neeraja C, Das K P, Mandal A K, Bhunia A (2016) Inhibition of Insulin Amyloid Fibrillation by a Novel Amphipathic Heptapeptide: Mechanistic Details Studied by Spectroscopy in Combination with Microscopy. *J. Biol. Chem.* 291, 23545-23556.

Dr. P. Chakrabarti

Senior 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. The potency of zinc oxide nanoparticles (Nps), with a core size of ~3-7 nm, to inhibit cholera disease was investigated by demonstrating the effect on two biotypes of O1 serogroup of *Vibrio cholerae* – El Tor was more

susceptible. Interaction with ZnO NP and the resulting stressed condition of treated bacterial cells were revealed by flow cytometric analysis and scanning electron microscopy. Increased fluidity and depolarization of membrane, and protein leakage further confirmed the damages inflicted on Vibrio by NP. NP was shown to produce reactive oxygen species (ROS) and induce DNA damage. These results suggest that the antibacterial mechanism of ZnO action is most likely due to generation of ROS and disruption of bacterial membrane. The synergistic action of NP and antibiotic, and the effect of NP on biofilm have been studied. The antimicrobial efficacy of NP has been validated in animal model by performing mouse ileal loop assay.

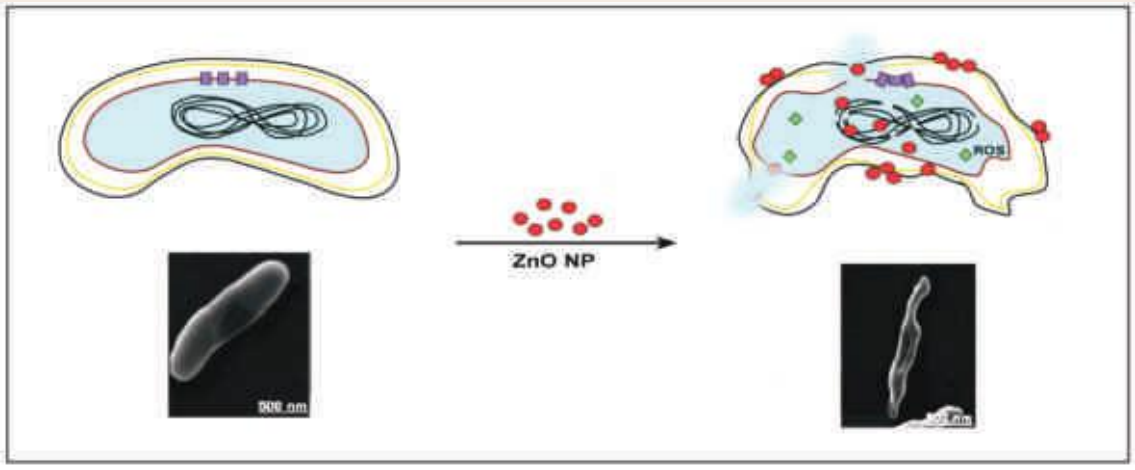


Figure: Morphological changes of *V. cholerae* cell and the disruption of its membrane in presence of ZnO NP

Publications :

1. Aoun J, Hayashi M, Sheikh IA, Sarkar P, Saha T, Ghosh P, Bhowmick R, Ghosh D, Chatterjee T, Chakrabarti P, Chakrabarti MK, Hoque KM (2016) Anoctamin 6 contributes to Cl^- secretion in accessory cholera enterotoxin (Ace) stimulated diarrhea: an essential role for PIP2 signaling in cholera. *J Biol Chem*, 291: 26816-26836.
2. Ghosh T, Barik S, Bhuniya A, Dhar J, Dasgupta S, Ghosh S, Sarkar M, Guha I, Sarkar K, Chakrabarti P, Saha B, Storkus WJ, Baral R and Bose A (2016) Tumor-associated mesenchymal stem cells inhibit naïve T cell expansion by blocking cysteine export from dendritic cells. *Int J Cancer*, 139: 2068-2081.
3. Karaman DS, Sarwar S, Desai D, Björk EM, Odén M, Chakrabarti P, Rosenholm JM and Chakraborti S (2016) Shape engineering boosts antibacterial activity of chitosan coated mesoporous silica nanoparticle doped with silver: a mechanistic investigation. J. Mater. Chem. B, 4: 3292-3304.
4. Sarwar S, Chakraborti S, Bera S, Sheikh IA, Hoque KM and Chakrabarti P (2016) The antimicrobial activity of ZnO nanoparticles against *Vibrio cholerae*: Variation in response depends on biotype. *Nanomedicine,* 12: 1499-1509.

Dr. Subhrangsu Chatterjee

Associate Professor & Ramanujan Fellow

Scientific Reports

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

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

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 and Chatterjee S (2016) Skeleton selectivity in complexation of chelerythrine and chelerythrine-like natural plant alkaloids with the G-quadruplex formed at the promoter of c-MYC oncogene: in silico exploration. *RSC Advances* 6(43):36667-36680. IF = 3.2
2. Chakraborty S, *et al.* (2016) Mephebrindole, a synthetic indole analog coordinates the crosstalk between p38MAPK and eIF2α/ATF4/CHOP signalling pathways for induction of apoptosis in human breast carcinoma cells. *Apoptosis*. IF = 3.6
3. Jagannath Jana, Pallabi Sengupta, Soma Mondal and Subhrangsu Chatterjee (2017) Restriction of telomerase capping by short non-toxic peptides *via* arresting telomeric G-quadruplex. *RSC Advances* 7, 20888.IF = 3.2
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. Kaulage M, *et al.* (2016) Discovery and Structural Characterization of G-quadruplex DNA in Human Acetyl-CoA Carboxylase Gene Promoters: Its Role in Transcriptional Regulation and as a Therapeutic Target for Human Disease. J *Med Chem* 59(10):5035-5050. IF = 5.6

6. Mondal S, Jana J, Sengupta P, Jana S, & Chatterjee S (2016) Myricetin arrests human telomeric G-quadruplex structure: a new mechanistic approach as an anticancer agent. *Mol Biosyst*. IF = 2.89

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

8. Saha T, Manna A, Bhat J, Chatterjee S, & Sa G (2016) G-actin guides p53 nuclear transport: potential contribution of monomeric actin in altered localization of mutant p53. Sci Rep. 2016 Sep 7;6:32626.IF = 5.2

9. 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

SCIENTIFIC REPORTS

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

We are involved in studying the effect of shape and size of gold nanoparticles on the growth of *Vibrio cholera*, classical and El tor biotypes, and on the structure of some of its toxins, with the aim of discovering new nanomedicines as alternative to antibiotics. Accessory cholera enterotoxin (Ace) is a classical enterotoxin produced by *Vibrio cholerae*, the causative agent for cholera. Considering the crucial role of

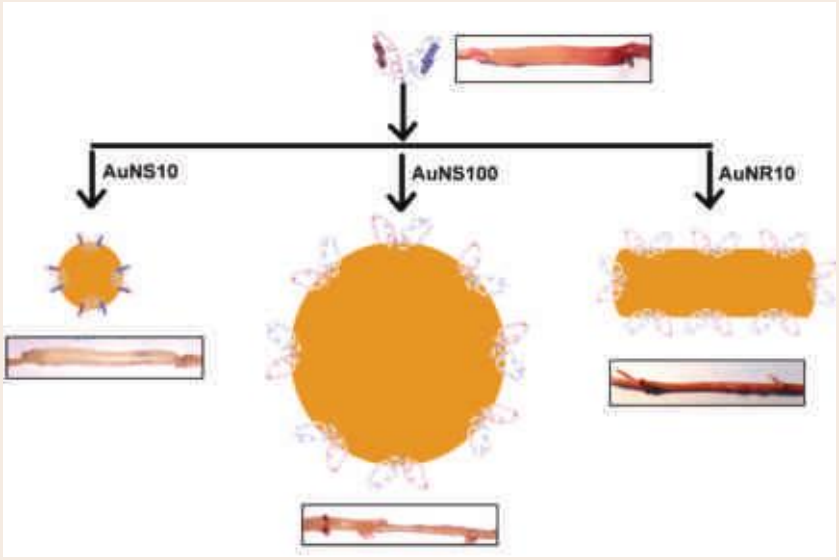


Figure: Effect of AuNPs (spheres of different size and rod) on the structure of Ace and Ace stimulated intestinal fluid accumulation.

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.

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

Cholera pathogenesis occurs due to synergistic pro-secretory effects of several toxins, such as cholera toxin (CTX) and Accessory cholera enterotoxin (Ace) secreted by *Vibrio cholerae* strains. Ace activates chloride channels stimulating chloride/bicarbonate transport that augments fluid secretion resulting in diarrhea. These channels have been targeted for drug development. We have studied the signaling mechanism and identified the chloride channel required for the activation of Ace for stimulating secretory diarrehea.

Publications :

1. Aoun J, Hayashi M, Sheikh IA, Sarkar P, Saha T, Ghosh P, Bhowmick R, Ghosh D, Chatterjee T, Chakrabarti P, Chakrabarti MK, Hoque KM (2016) Anoctamin 6 contributes to Cl^- secretion in accessory cholera enterotoxin (Ace) stimulated diarrhea: an essential role for PIP2 signaling in cholera. *J Biol Chem*, 291, 26816-26836.
2. 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.

Grants-In- Aid Schemes :

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

Dr. Rajagopal Chattopadhyaya

Professor

Scientific Reports

Influence of Plant Extracts on Fenton-reaction mediated DNA damage

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

More on RecA as a co-protease

It has been shown experimentally using MALDI-TOF that His 163 of RecA is probably involved in one of the important among several parallel pathways leading to the RecA-mediated cleavage of lambda cI, LexA and kindred repressors.

Crystal structure of *Colocasia esculenta* lectin solved with mannose

High resolution X-ray crystallographic data were collected in late 2014 in our Institute facility for two kinds of crystals of *Colocasia esculenta* (wild taro, called 'gnati kochu' in Bengali) tuber lectin, with and without mannose bound. The lectin molecule is composed of two distinct polypeptide chains, i.e., it is a heterodimer. The mannose-free lectin crystallized in space group $P222_1$ with cell parameters a = 122.01Å, b = 47.20Å, c = 82.25Å, $\alpha = \beta = \gamma$ = 90.00 degrees. The structure and its solution were described in some detail in last year's annual report.

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

Publications :

1. Chattopadhyaya, R, Biswas, H & Sarkar, A (2017) Crystal structure *Colocasia esculenta* tuber agglutinin at 1.74Å resolution and its quaternary interactions. *Journal of Glycobiology*, 6:2. doi: 10.4172/2168-958X.1000126
2. Kar, I & Chattopadhyaya, R (2016) Effect of seven Indian plant extracts on Fenton reaction-mediated damage to DNA constituents. *Journal of Biomolecular Structure and Dynamics*, http://dx.doi.org/10.1080/07391102.2016.1244493
3. Kar, I & Chattopadhyaya, R (2016) Role of Histidine163 in the co-protease Activity of RecA Verified by Chemical Modification, followed by Maldi mass Spectrometry. *Science and Culture*, 82 (11-12), 382-385.
4. Kar I, Majumder H K & Chattopadhyaya, R (2017) Extracts of Seven Indian Plants Inhibit Human Topoisomerase I and Partially Inhibit Human Topoisomerase II. *Molecular Enzymology and Drug Targets*, 3 (1):1. http://www.imedpub.com

Students awarded Ph.D. :

Name of Student (University/ Year)	Title of Thesis
Himadri Biswas (C.U., 2016)	Isolation, characterization and crystallographic studies of different mannose-binding Plant lectins, and model building of enteropathogenic *E. coli*, enterotoxigenic E. coli type IVb pilins

Dr. K. P. Das

Senior Professor

Scientific Reports

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

Using acrylodan labeled α-crystallin at 250 mg/ml concentration, the decay of solvent correlation function in presence and absence of different small molecules have been measured. The solvent correlation data reveals that while dilute a-crystallin (5 mg/ml) solution shows a solvation time of 200 ps, concentrated (250 mg/ml) solution contains a heterogeneous population of solvent molecules having salvation time ranging from 600 to 1500 ps. It appears that addition of 3 mM ATP reduces the heterogeneity of the solvent dynamics. Further analysis is in progress.

Publications :

1. Das P, Mandal S, Gangopadhyay S, Das KP, Ghosh A, Dasgupta S, Mukhopadhyay Soma, Mukhopadhyay A (2016) Antioxidative and anticarcinogenic activities of

methylpheophorbide a, isolated from wheat grass (*Triticum aestivum* Linn.), *Natural Product Research*, 30(4), 474–477.

2. Ghosh D Chattoraj, D K, Chattopadhyay, P and Das, K P (2016) Kinetics of conversion of cow milk and soy milk curd to gels by fermentation process at acid pH, *J. Surface Sci. Technol.*, 32, 1-6.
3. Ratha B N, Ghosh A, Brender J R, Gayen N, Ilyas, H, Neeraja, C, Das K P, Mandal A K and Bhunia A (2016) Inhibition of isulin amyloid fibrillation by a novel amphipathic heptapeptide: mechanistic details studied by spectroscopy in combination with microscopy, *J. Biol. Chem.*, 291(45), 23545-23556.
4. Roy S and Das K P (2017) Homologous recombination defective Arabidopsis mutants exhibit enhanced sensitivity to abscisic acid, *PLoS One,* 12(1), e0169294.

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

Delivered an invited talk on February 4, 2017 at a seminar held at the Techno India University, Salt lake, Sector V, Kolkata

Dr. Ajit Bikram Datta

Associate Professor & Wellcome Trust DBT India Alliance Fellow

Scientific Reports

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

Post-translational modification of proteins via conjugation of ubiquitin is a remarkably conserved cellular process that exists in all eukaryotic organisms. Consequently, this process has been implicated in a wide spectrum of cellular processes that include DNA repair, regulation of transcription, cell-cycle control, cellular signaling apart from its well-established role in cellular proteostasis. A brief search of the scientific literature shows that defects in the ubiquitination pathways have been implicated in a number of pathophysiologic conditions including various types of cancers as well as neurodegenerative disorders. Ubiquitin is a small 76 residue protein that gets conjugated to a plethora of substrate proteins in anspatio-temporally selective manner in response to appropriate biological signals via a cascade of three enzyme catalyzed steps. In the first step of this cascade E1 enzyme non-specifically activates all the Ub molecules and subsequently transfers them to conjugating E2 enzymes. These e2s in the third and final step of the reaction interacts with a specific ubiquitin E3 ligase that in turn engages its specific substrate and modifies the latter via isopeptide bond formations. Human genome codes for a wide repertoire of E2s (about 40) and E3 enzymes (> 1000), which, in a combinatorial manner dictates the substrate selection as well as the

modification topology, both being crucial for the specific cellular response. Thus the spatio-temporal specificities of E3-E2 and E3-substrate interaction and their regulations are crucial to elicit the desired the biological reaction.

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 2016-2017

A. Understanding the molecular basis of attenuated activity of Ube2Es

In an extension of our work on understanding E2 activity we have been able to understand the basis of the reduced catalytic activity of Ube2Es due to their inability to backbind"regulator Ub" molecules. Serendipitously, we have also been able to find out four residues in Ube2E that are placed both sequentially as well as structurally apart in the protein but regulates the backbinding mediated effect on the E2 activity.

B. Structure of ZNRF1 in complex with Ube2N ~ Ub mimic

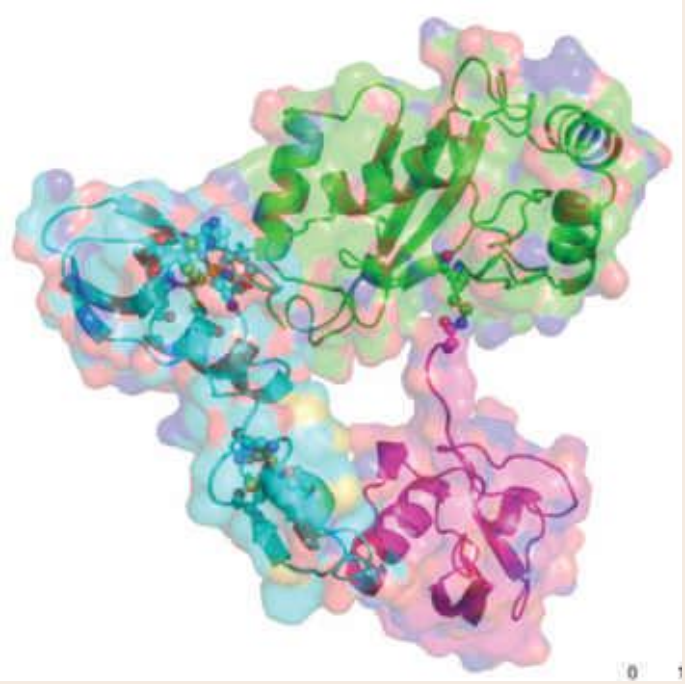


Figure 1.Crystal structure of ZNRF1(cyan) in complex with Ube2N(green) ~ Ub conjugate.

further in an attempt to determine the molecular mechanism of E2 ~ Ub activation by ZNRF1. We have been able to solve the structure of this E3 in complex with a charged analogue of Ube2N ~ Ub intermediate (Figure 1). This structure in addition to the previous determined structure of the E3:E2 complex structure

Last year we obtained the structure of an E3 ligase ZNRF1 in complex with its cognate E2, Ube2N, at 1.5Å resolution. This year we have extended our work

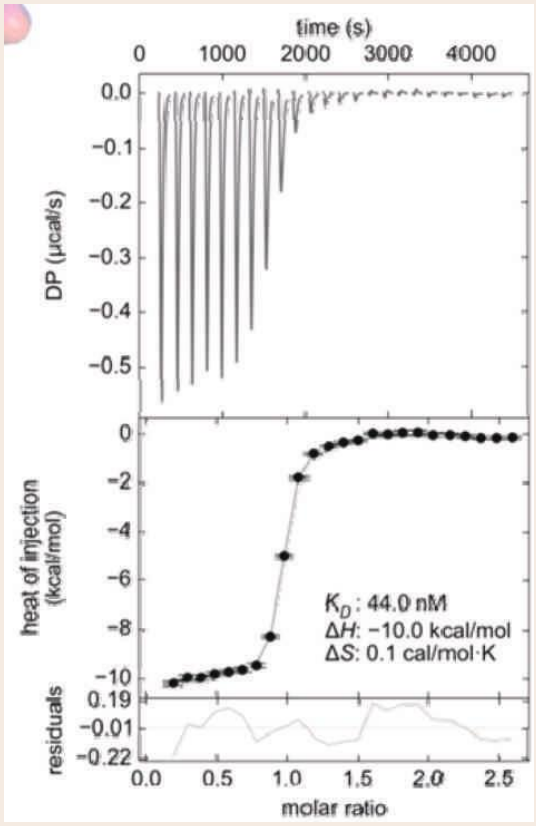


Figure 2.Isothermal titration calorimetry data showing the binding of ZNRF1 to Ube2N

provided us with valuable insights into the molecular basis ZNRF1 activity. We also found that unlike all other E3s studied till date ZNRF1 could bind to its cognate E2 Ube2N with nanomolar affinity (Figure 2). In an attempt to understand the molecular mechanism behind such unprecedented E3:E2 binding and basis of E2 discrimination by E3 ligases we identified a few E2 residues in the core UBC domains that bring subtle structural changes in the E2. And these residue play equally critical role in regulating the E3 specificity of E2 enzymes.

C. Structure of Uba6 Ubiquitin fold domain

Figure 3.Crystal structure of Uba6-Ufd domain at 2.0 Å.

In most eukaryotes ubiquitin is activated by a single ubiquitin conjugating E1 enzyme known as the Uba1. In higher mammals including humans, however, there exists a second E1 enzyme that displays dual specificity for ubiquitin and an UbL called FAT10. This E1 however does not deliver its activated Ub to all the E2s common to Uba1 but only to a subset of them along with E2s specific for itself. We have determined the crystals structure of Uba6-Ufd domain that primarily confers E2 selectivity of this enzyme (Figure 3). Further studies are underway to determine the E2 specificity of Uba6.

Dr. Jayanta Mukhopadhyay

Associate Professor

Scientific Reports

Novel functions of δ factor from *Bacillus subtilis* as transcriptional regulator

δ, a small protein found in most Gram-positive bacteria was, for a long time, thought to be a subunit of RNA polymerase (RNAP) and was shown to be involved in recycling of RNAP at the end of each round of transcription. However, how δ participates in both up-regulation and down-regulation of genes *in vivo* remains unclear. We have recently shown δ in addition to the recycling

of RNAP, δfunctions as a transcriptional activator by binding to an A-rich sequence located immediately upstream of the -35 element, and consequently facilitating the open complex formation. The result had explained the mechanism of up-regulation of the genes by δ .

We further showed that *Bacillus subtilis* δ ?ould also function as a transcriptional repressor. Our results demonstrated that δ binds to an A-rich sequence located near the -35 element of the *spo0B* promoter, the gene involved in the regulatory cascade of bacterial sporulation and inhibits the open complex formation due to steric clash with δ region 4.2. We observed a significant increase in the mRNA level of the *spo0B* gene in a δ knockout strain of *B. subtilis* compared to the wild-type. Thus, the results report a novel function of δ, and suggest the mechanism of down-regulation of genes *in vivo* by the protein.

Dr. Pradeep Parrack

Professor

Student awarded Ph.D :

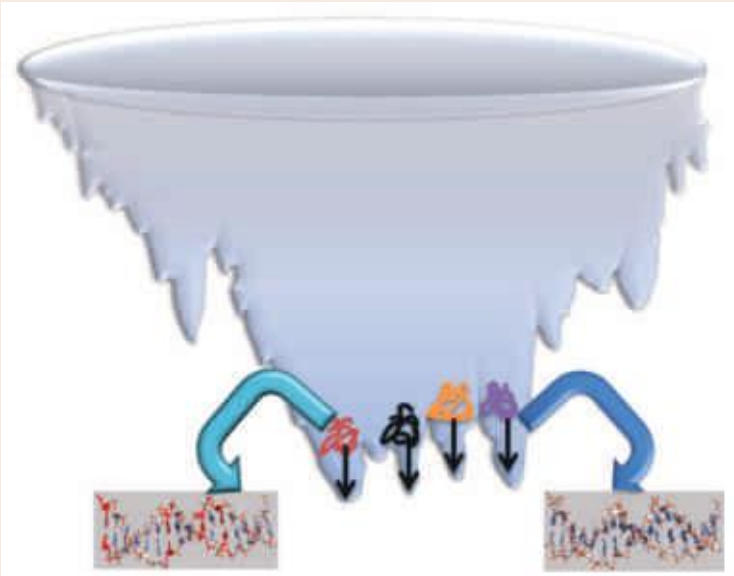
Name of Student (University/ Year)	Title of thesis
Avisek Mondal (C.U., 2016)	Structural Studies on the C1 protein of bacteriophage P22

Dr. Siddhartha Roy

Senior Professor, Dean of Studies & Director (Officiating)

Scientific Reports

Transcription factors recognize short DNA sequences present within the billions of basepairs in the genome. How the transcription factors recognize these sequences specifically is not fully understood. We have elucidated two important aspects of the DNA-protein interaction that are important components of the recognition process. We have shown that the specific DNA sequences induce allosteric changes in the bound transcription factors, which in turn affects interactions of the transcription factors, both in *cis* and in *trans*, thus enhancing the specificity of gene regulation. We have also demonstrated that recognition of multiple DNA sequences by the same transcription factor is caused by preferential interaction of different pre-existing conformations with different DNA sequences.



Tumors bearing activating mutations in the RAS proteins are very difficult to treat. CFOS is a proto-oncogene and is constitutionally up-regulated in RAS mutated cells. We have shown that a peptide-based synthetic transcription factor was able to down-regulate the CFOS gene in a RAS-mutant tumor cell, by binding specifically to the promoter elements of the gene. This should open up a novel way of counteracting the oncogenic mutations.

Publications :

1. Roy S, Bhattacharya N , Stubblefield P G (eds.) (2016) Gene Regulatory Networks and Epigenetic Modifications in Cell Fate Decisions During the Early Embryonic Development., *Human Fetal Growth and Development: First and Second Trimesters*, Springer International Publishing Switzerland. DOI 10.1007/978-3-319-14874-8_13
2. Choudhury S, Ghosh B, Singh P, Ghosh R, Roy S, Pal SK (2016) Ultrafast differential flexibility of Cro-protein binding domains of two operator DNAs with different sequences. *Phys Chem Chem Phys*. Jul 21;18(27):17983-90.
3. Choudhury S, Naiya G, Singh P, Lemmens P, Roy S, Pal SK (2016) Modulation of Ultrafast Conformational Dynamics in Allosteric Interaction of Gal Repressor Protein with Different Operator DNA Sequences, *Chembiochem*. Apr 1;17(7):605-13.
4. Naiya G, Raha P, Mondal M Kumar, Pal U, Saha R, Chaudhuri S , Batabyal S, Pal S Kumar, Bhattacharyya D, Maiti N C and Roy S (2016) Conformational selection underpins recognition of multiple DNA sequences by proteins and consequent functional actions. *. *Phys. Chem. Chem. Phys.,* 18: 21618-21628
5. Chakraborty M and Roy S (2016) A Peptide-based Synthetic Transcription Factor Selectively Down-regulates the Proto-oncogene CFOS in Tumour Cells and Inhibits Proliferation. *Chem. Commun*., Dec 22; 53(2):376-379.

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

Invited lecture on (i) Queenstown Molecular Biology meeting in Shanghai, China, 2017; (ii) International Chemical Biology Society annual meeting, Madison, Wisconsin, USA, 2016; (iii) Asian Chemical Biology Initiative, Ho Chi Minh City, Vietnam, 2017.

Awards / Honors received:

i. Appointed Member of Editorial Advisory Board, Molecular Pharmacology, The American Society for Pharmacology and Experimental Therapeutics (ASPET).

ii. Appointed Chair, Internal Review Board, Tata Medical Center, Kolkata.

iii. Nominated to Board of Directors, International Chemical Biology Society.

Prof. Anand Bacchawat of IISER Mohali delivering a lecture at the symposium 'The world of Microbes: Pathogenesis, Environment and Evolution' organized by Bose institute to commemorate 100 years of its existence.

Tea session at the symposium on 'The world of Microbes: Pathogenesis, Environment and Evolution' organized by Bose institute to commemorate 100 years of its existence.

A research scholar delivering a talk at the symposium on 'The world of Microbes: Pathogenesis, Environment and Evolution' organized by Bose institute to commemorate 100 years of its existence.

Poster session at the symposium on 'The world of Microbes: Pathogenesis, Environment and Evolution' organized by Bose institute to commemorate 100 years of its existence.

The audience at the Symposium on 'The world of Microbes: Pathogenesis, Environment and Evolution' organized by Bose institute to commemorate 100 years of its existence.

SCIENTIFIC REPORTS III

Computational Biology

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

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

Introduction

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

Dr. Gautam Basu

Senior Professor

Scientific Reports

Differential dynamics between animal and non-animal tubulin

Tubulin is a hetero-dimeric protein that plays a crucial role in cell division (microtubules) and therefore is a major target for anti-cancer drugs. Colchicine is a naturally occurring small molecule that binds tubulin (at the dimer interface) and hinders microtubule formation leading to arrest of cell division. Although colchicine binds animal tubulin strongly, its binding non-animal tubulin (fungi, protest or plant) is weak. Previously we had identified specific amino acid residues responsible for the differential binding but the mechanism was not clear. By performing a series of long MD simulations of animal and yeast tubulin and their mutants, we have identified the molecular mechanism that gives rise to the differential binding. Specifically, we show that T-loop dynamics play a major role.

Differential dynamics between anticodon arm and loop of $tRNA^{Gln}$ with specific base-pairs at 32:38 position

Previous studies in our lab showed that specific base-pairs at 32:38 position in $tRNA^{Gln}$ determines its specificity to discriminatory or non-discriminatory GluRS. By performing a series of long MD simulations on $tRNA^{Gln}$ anticodon arm and loop, with distinct anticodon triplet and base pair at 32:38 position, we are investigating differential dynamics between the two forms which might be responsible for their differential behavior towards discriminatory and non-discriminatory GluRS.

Publications :

1. Dasgupta R, Ganguly H K , Modugula E K, Basu G (2017) Type VIa -turn-fused helix N-termini: A novel helix N-cap motif containing *cis* proline. *Biopolymers* doi: 10.1002/bip.22919. IF: 2.248

Dr. P. Chakrabarti

Senior Professor and Coordinator

Scientific Reports

Weak non-bonded interactions in the stabilization of protein structures: Identification of a new secondary structure

Over the past several years we have been analyzing protein structures to identify the manifestation of weak, but geometrically well-defined non-bonded interactions that can stabilize small local structures, which can also be seen in the isolated peptide moieties. An analysis of protein structures indicates the existence of a novel, fused five-membered rings motif, comprising of two residues (i and i + 1), stabilized by interresidue N_{i+1}- H···N_i and intraresidue N_{i+1}- H···O = C_{i+1} hydrogen bonds. Fused-rings geometry is the common thread running through many commonly occurring

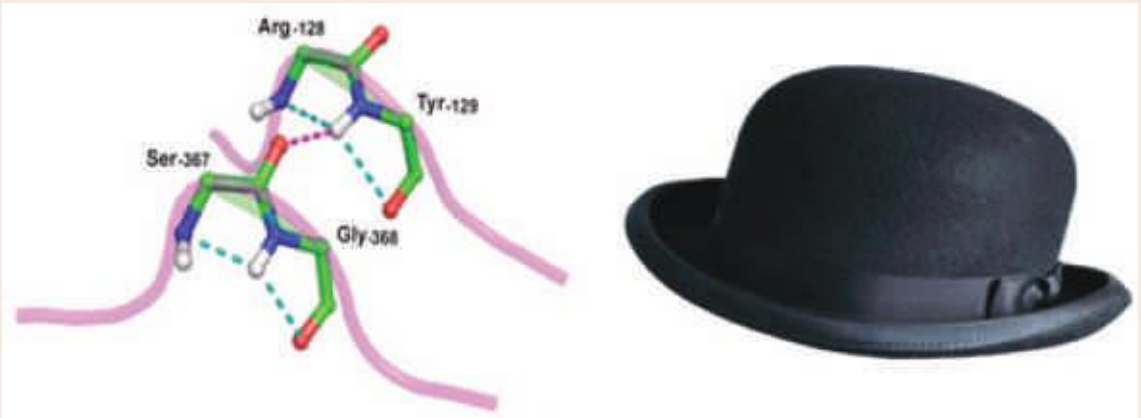


Figure: A new protein secondary structure, *Topi*

motifs, such as β-turn, β-bulge, Asx-turn, Ser/Thr-turn, Schellman motif, and points to its structural robustness. The fused-rings structures, distant from each other in sequence, can hydrogen bond with each other, and the two segments aligned to each other in a parallel fashion, give rise to a novel secondary structure, *topi*, which is quite common in proteins, distinct from two major secondary structures, α-helix and β-sheet, proposed by Linus Pauling. The secondary structure has been termed *topi* (the term used for hat in many Indian languages). Thus an Indian term has been introduced in scientific lexicon.

Structural changes accompanying protein-protein complex formation

To delineate features that characterize protein-protein interactions is a long-standing theme in our group. We have extended the work to protein-RNA interaction, and classified the interfaces based on the composition of the secondary structural elements located in the interface.

Publications :

1. Biswas S and Chakrabarti P (2016) Analysis of interactions and dissection of interfaces involved in RNA-protein recognition. *Protein & Peptide Letters,* 23: 777-784.
2. Dhar J, Kishore R and Chakrabarti P (2016) A novel secondary structure based on fused five-membered rings motif. *Scientific Reports*, 6:31483.

Grants- In- Aid Schemes :

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

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

Presented papers and attended at (i) 1st Pan-African Conference on Crystallography, PCCr1, University of Dschang, Cameroon, October 6 – 10, 2016 (ii) the 27th TWAS General Meeting, Kigali, Rwanda, November 14-17, 2016 (iii) the 14th Conference of the Asian Crystallogrpahic Association (AsCA 2016), Hanoi, Vietnam, December 4 – 7, 2016 (iv) the 3rd International Conference on Perspectives of Cell Signaling and Molecular Medicine, Bose Institute, January 8 – 10, 2017 (v) XXVIII Annual Bioinformatics Coordinators Meeting, ACTREC, Navi Mumbai, February 3 – 4, 2017 (vi) Symposium on Organic Molecules: Syntheses & Applications (OMSA), IIT Kharagpur, February 17 – 18, 2017 (vii) delivered a talk on the occasion of the birthday of Acharya P. C. Ray to school children, organized by the Department of Chemistry, IIT, Kharagpur, August 2, 2016 (viii) Chief Guest address at the valedictory function of the Computer Science Association, Department of Computer Science, Bharathiar University, Coimbatore, February 23, 2017.

Group members :

Shamila Sarwar, Avisek Mondal, Swapan Jana and Supriyo Bera attended the symposium, *The World of Microbes: Pathogens, Environment and Evolution*, Bose Institute, October 17, 2016.

Shamila Sarwar attended the 85th Annual Meeting of the Society of Biological Chemistry, Mysore, November 21 – 24, 2016.

Swapan Jana attended the 5th Symposium on *Advanced Biological Inorganic Chemistry*, Kolkata, January 7 – 11, 2017.

Shamila Sawar and Supriyo Bera attended One Day *Symposium on Nanotechnology: From Materials to Medicines and their Social Impact*, Birla Industrial & Technological Museum, March 25, 2017.

Awards / Honours received :

The Jagadis Chandra Bose Medal, INSA (2016).

Dr. Tapan K. Dutta

Professor

Scientific Reports

Bioinformatic analyses of bacterial ring-hydroxylating oxygenases

Naphthalene dioxygenase (NDO) has a buried active site, containing mono-nuclear Fe^{2+} center, which was found to be connected with the external environment via three tunnels, identified using tunnel detection algorithm of MOLE 2.0. The major objective of our work was to identify the channel/channels involved in substrate-entry into the active site and product-egress into the external environment. The naphthalene dioxygenase operon, comprising of α-subunit, β-subunit, ferredoxin and reductase, was cloned into pET28 (a) using *E. coli* XL1Blue as cloning host. Then site-directed mutagenesis approach was carried out to block each tunnel by substituting the smaller amino acid with larger one. Three different mutant enzymes, namely G210M (G, 210th residue of wild type alpha subunit, replaced by M), I191W (I, 191th residue of wild type alpha subunit, replaced by W), A238L-L227Y (A, 238th residue of wild type alpha subunit, replaced by L; L, 227th residue, replaced by Y) were generated to block three channels, one for each channel. Activities of these mutants towards different aromatic compounds, varying in number of ring and polarity, were compared with that of wild type enzyme. Whole cell biotransformation study was performed and product was identified using TLC and GC-MS analyses. It was observed that the mutant A238L-L227Y did not transform any substrate indicating that the channel blocked in this mutant is the preferred path for either substrate entry or product egress or both. So this is the major channel and it might work in collaboration with other two channels, which is in progress.

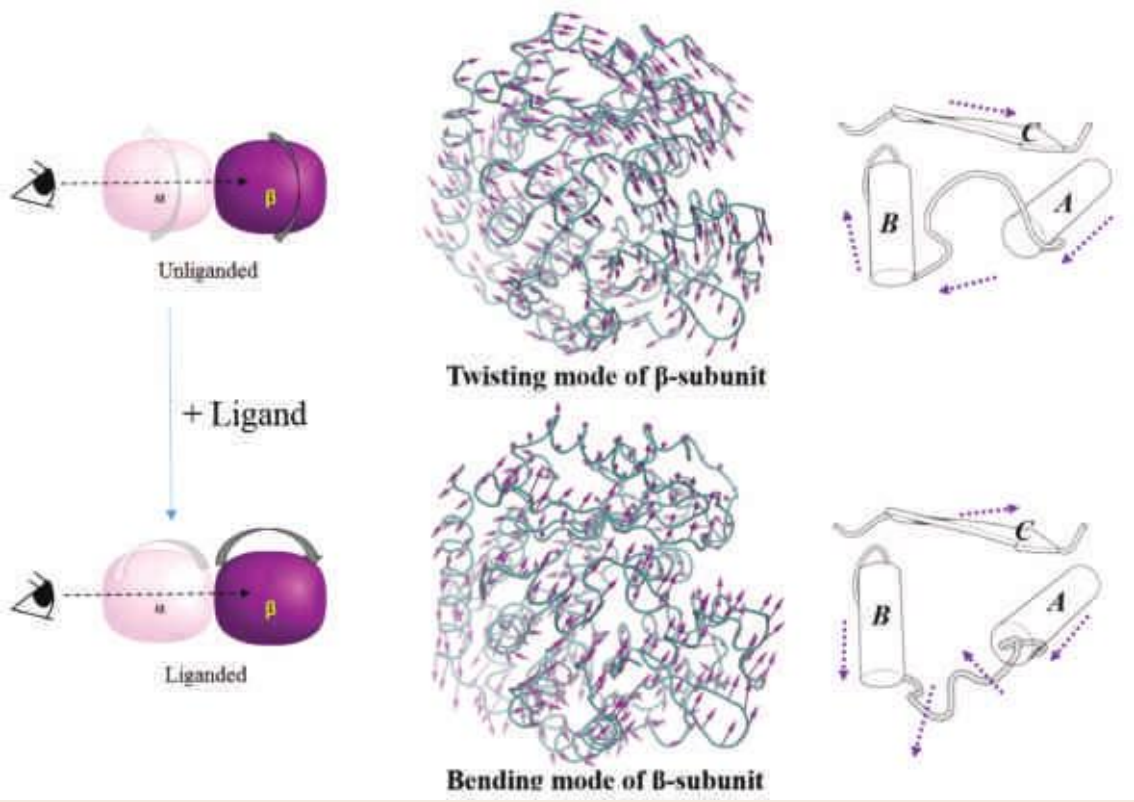
Dr. Shubhra Ghosh Dastidar

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 role of 'bridging water' in facilitating molecular recognitions, importance if micro-solvation in membrane-protein interactions, essential dynamics of proteins etc. We use latest technologies of high performance computing to perform carry out investigations and work in a truly interdisciplinary manner with active collaborations with experimentalists. An example of the recent results is the following:



The figure shows the essence of the recent findings on the mechanism of ligand induced perturbation on the internal motions of α,β-dimer of tubulin (Ref: J Phys Chem B. 2017;121(1):118-128). The work has revealed that the binding of a ligand at the interface of α and β subunits

changes the integrity of network between its several secondary structural elements which changes its preferred paths of protein's internal motions and thus alters the conformational sampling. This alternation in conformational sampling has direct correlation with its change in ability to form microtubules. Thus it reveals the mechanism of tubulin binding drugs to inhibit cellular growth by suppressing the microtubule formation.

Publications:

i) Maity A, Sinha S, Ganguly D, Ghosh Dastidar S (2016), C-terminal tail insertion of Bcl-xL in membrane occurs via partial unfolding and refolding cycle associating microsolvation, *Phys Chem Chem Phys*., 18(34):24095-105.

ii) Majumdar S, Ghosh Dastidar S (2017) (Epub 2016 Dec 21), Ligand Binding Swaps between Soft Internal Modes of α,β-Tubulin and Alters Its Accessible Conformational Space, *J Phys Chem B*., 121(1):118-128.

iii) Majumdar S, Maiti S, Ghosh Dastidar S (2016). Dynamic and Static Water Molecules Complement the TN16 Conformational Heterogeneity inside the Tubulin Cavity, *Biochemistry,* 55(2):335-47.

Grants-in-Aid Schemes :

Title of the Scheme	Schemes 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

Dr. Tapash C Ghosh

Senior Professor

Scientific Reports

Evolutionary Bioinformatics

The major theme of our research is to identify and understand different evolutionary forces by analyzing the genomic and functional data of various organisms to gain insight into the structural and functional organization of a genome. Very briefly, the major results of the last one year (2016-17) are as follows:

- Functional landscape of Overlapping Genes (OGs) across different taxonomic groups, mainly prokaryotes and viruses have been explored. It was observed that thermophilic prokaryotes exhibit higher overlap frequency than non-thermophiles. Long overlap

frequency (LOF) was found to hold a positive correlation with Optimal Growth Temperature (OGT) resulting in an abundance of long overlaps in thermophiles compared to non-thermophiles. On the other hand, short overlap (1-4 nucleotides) frequency (SOF) did not yield any direct correlation with OGT. However, the correlation of SOF with Codon Usage Bias (CAI_{avg}) and IG% (proportion of intergenic regions in the genome) indicate that they might upregulate the aforementioned factors (CAI_{avg} and IG%) which are already known to be vital forces for thermophilic adaptation. While, elucidating the genomic features influencing prokaryotic growth rates, we observed that the proportion of overlapping region holds a significant negative correlation with generation time in archaeal domain whereas, no correlation was observed in the eubacterial domain. However, after masking the effect of tRNA, rRNA multiplicity and environmental diversity, OGs show an independent effect over growth rates in the eubacterial domain as well as in the archaeal domain. Studies on HIV-1 virus revealed that overlapping regions show a significant bias towards disorder promoting residues and also has an enriched repertoire of eukaryotic linear motif (ELM). This in turn suggests that OGs in HIV-1 has an impact on virus-host interactome. In a nutshell, function of OGs in prokaryotic as well as viral domain is distinctive from each other.

- Comparisons of evolutionary features between human disease and non-disease genes have a wide implication to understand the genetic basis of human disease genes. However, it has not yet been resolved whether disease genes evolve at slower or faster rate than the non-disease genes. To resolve this controversy, here we integrated human disease genes from several databases and compared their protein evolutionary rates with non-disease genes in both housekeeping and tissue-specific group. We noticed that in tissue specific group, disease genes evolve significantly at a slower rate than non-disease genes. However, we found no significant difference in evolutionary rates between disease and non-disease genes in housekeeping group. Tissue specific disease genes have a higher protein complex number, elevated gene expression level and are also associated with conserve biological processes. Finally, our regression analysis suggested that protein complex number followed by protein multifunctionality independently modulates the evolutionary rate of human disease genes.

- In mammals, it has long been suggested that brain-specific genes (BSGs) and widely expressed genes (WEGs) have seemingly lower dN/dS ratio than any other gene sets. However, to what extent these genes differ in their dN/dS ratio has still remained controversial. Here, we have revealed lower dN/dS ratio of BSGs than WEGs in human-mouse, human-orangutan, human-chimpanzee and mouse-rat orthologous pair. The significance level of dN/dS ratio difference indicates a trend of decreasing difference as complexity of compared pairs increases. Further studies with the human-mouse pair revealed that, removal of the duplicated genes from both the dataset has nullified this difference which dictates a vital role of duplicated genes in governing the selection pressure. Conclusively, higher paralog number, expression level, and longer regulatory region length of BSGs allow fewer nucleotide substitutions within them. Our results show for the first time to our knowledge lower dN/dS ratio of BSGs than WEGs.

Publications :

1. Begum T, Ghosh TC, Basak S (2017) Systematic Analyses and Prediction of Human Drug Side Effect Associated Proteins from the Perspective of Protein Evolution. *Genome Biol Evol* 9(2): 337-350.
2. Biswas K, Chakraborty S, Podder S, Ghosh TC (2016) Insights into the DN/Ds ratio heterogeneity between brain specific genes and widely expressed genes in species of different complexity. *Genomics* 108: 11-17.
3. Chakraborty S, Panda A, Ghosh TC (2016) Exploring the evolutionary rate differences between human disease and non-disease genes. *Genomics* 108: 18-24.
4. Das M, Haberer G, Panda A, Das Laha S, Ghosh TC, Schäffner AR (2016) Expression Pattern Similarities Support the Prediction of Orthologs Retaining Common Functions after Gene Duplication Events. *Plant Physiol* 171(4): 2343-2357.
5. Saha D, Podder S, Panda A, Ghosh TC (2016) Overlapping genes: A significant genomic correlate of prokaryotic growth rates. *Gene* 582(2): 143-147.
6. Saha D, Podder S, T C Ghosh (2016) Overlapping Regions in HIV-1 Genome Act as Potential Sites for Host-Virus Interaction. *Front Microbiol.* 2016 Nov 4;7:1735. E-Collection.
7. Satapathy SS, Sahoo AK, Ray SK, Ghosh TC (2017) Codon degeneracy and amino acid abundance influence the measures of codon usage bias: improved Nc (N'c) and ENCprime (N'c) measures. *Genes Cells*. 22 (3): 277-283.
8. Sen K, Sarkar A, Maji RK, Ghosh Z, Gupta S, Ghosh TC (2016) Deciphering the cross-talking of human competitive endogenous RNAs in K562 chronic myelogenous leukemia cell line *Mol Biosyst*. 12(12): 3633-3642.

Students awarded Ph.D.:

Name of Student (University/ Year)	Title of Thesis
Arup Panda (C.U., 2016)	The role of protein of protein structural disorder on the evolutionary features of prokaryotic and eukaryotic genomes

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

i. March 29,2017 IISER, Kolkata, India

ii. March 27, 2017 NICED, Kolkata, India

iii. January 2017 at Rajshahi University, Bangladesh

iv. March 1, 2017 at Nagaland Central University, Nagaland

Member of Editorial Board :

(i) BMC Genomics (From 2010 -)

(ii) Evolutionary Bioinformatics (From 2013-)

Dr. Zhumur Ghosh

Assistant Professor

Scientific Reports

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.

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

Publications :

1. Kundu M, Mahata B, Banerjee A, Chakraborty S, Debnath S, Ray SS, Ghosh Z, Biswas K. (2016) Ganglioside GM2 mediates migration of tumor cells by interacting with integrin and modulating the downstream signaling pathway. *Biochim Biophys Acta.* 2016; S0167-4889(16)30085-4. PMID: 27066976.

2. Roy, J, Sarkar A, Parida S, Ghosh Z & Mallick B (2017) Small RNA sequencing revealed dysregulated piRNAs in Alzheimer's disease and their probable role in pathogenesis. *Mol Biosyst*. DOI: 10.1039/C6MB00699J.

3. Sarkar D, Maji R, Dey S Sarkar, A, Ghosh Z & Kundu P (2017) Integrated miRNA and mRNA expression profiling reveals the response regulators of a susceptible tomato cultivar to early blight disease. *DNA Research* (doi: 10.1093/dnares/dsx003)

4. Sen K, Sarkar A, Maji R K, Ghosh Z, Gupta S & Ghosh TC (2016) Deciphering the cross-talking of human competitive endogenous RNAs in K562 chronic myelogenous leukemia cell line. *Mol Biosyst*. 12(12):3633-3642.

In conference proceedings :

1. Sarkar A, Ghosh Z (2017) Elucidating the role of piRNAs in Ovarian teratocarcinoma, Keystone Symposia "Noncoding RNAs: From Disease to Targeted Therapeutics", Alberta, Canada.

Grant-in-Aid Schemes :

Title of the Scheme	Schemes funded by
Elucidating the GWAS-Associated Genetic Variants within lncRNA candidate loci: Role in Cancer *With Dr. Sudipto Saha*	SERB
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 Members :

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.

Awards / Honors received :

Editorial Board Member, Current Bioinformatics

Socially Relevant :

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

Dr. Debjani Roy

Assistant Professor

Scientific Reports

Drug repositioning of Parkinson's Disease from Genetic variation data

Single nucleotide polymorphisms (SNPs) are the most common type of sequence variation between individuals and represent an efficient method for finding genetic determinants of complex disease and understanding the differences in drug response. We have identified several PD-related SNPs and their respective genes from high-throughput sequencing data. Based on these findings, we designed a pipeline and proposed several repositioning drugs for PD.

Understanding the genomic methylation profiling of Parkinson's Disease: A computational perspective

Bisulfite sequenced DNA methylation profiling of Next-Generation Sequencing data of Parkinson's disease (PD) was analyzed. Analyses led to the identification of methylation genes which contained differentially methylated CpGs. Drugs associated with these genes were identified. We further integrated our networks with several enrichment analyses. The finding of our work will help to better direct future studies aimed to unravel the epigenetic participation in PD.

In Silico Approaches to developing DNA methyltransferase inhibitors

DNA methylation is an important epigenetic change which regulates gene expression in the genome by DNA methyltransferases (DNMTs). The identification of DNMT inhibitors is an efficient method to develop therapeutic strategies for several complex diseases. We are employing several *in silico* approaches, i.e., screen chemical databases, mine the DNMT-relevant chemical space and designed libraries for the development of DNMT inhibitors.

Publications:

1. Chatterjee P, Roy D (2017) Comparative analysis of RNA-Seq data from brain and blood samples of Parkinson's disease., *Biochem Biophys Research Communication*. 484(3):557-564. doi: 10.1016/j.bbrc.2017.01.121. Epub 2017 Jan 26. PMID:28131841.
2. Chatterjee P, Roy D (2016) Insight into the epigenetics of Alzheimer's disease: A computational study from human interactome, *Current Alzheimer Research*. 13(12):1385-1396.doi: 10.2174/1567205013666160803151101. PMID: 27492077.
3. Chatterjee P, Roy D (2016) Structural insight into GRIP1-PDZ6 in Alzheimer's disease: study from protein expression data to molecular dynamics simulations, *Journal of Biomolecular Structure and Dynamics*. (2016) 1:1-13. DOI: 10.1080/07391102.2016.1214085. PMID: 27425598.

Dr. Sudipto Saha

Assistant Professor and Ramalingaswami Fellow

Scientific Reports

Identification of linear peptides in cancer-associated hub protein that can mediate multiple protein-protein interactions

A computational framework has been develop for predicting linear peptide(s) on three hub proteins-MYC,APC and MDM2 that allow them to interact with multiple proteins. A scoring system was used to rank the peptides and two peptides from MYC were tested for experimental validation using Y-2H based method.

Prediction of proteins involved in pluripotency protein-protein interaction network from sequence features

Machine learning techniques (MLTs) such as Support Vector Machine (SVM), Naïve Base (NB), Random Forest (RF), and sequence alignment technique BLAST were used predict proteins involved in pluripotency network. The combination of SVM and PSI-BLAST was our proposed best model, which obtained an accuracy of 79.2 percent, and area under the ROC curve was 0.82 using 5-fold cross-validation. PluriPred web server was developed and using it, 233 novel core and 323 novel extended core pluripotent proteins from mouse proteome, and 167 novel core and 385 extended core pluripotent proteins from human proteome, were predicted with high confidence.

Publications :

1. Mandal S D and Saha S (2016) PluriPred: AWeb server for predicting proteins involved in pluripotent network. *J Biosci*. 41, 743-750.
2. Sarkar D, Patra P, Ghosh A and Saha S (2016) Computational Framework for Prediction of Peptide Sequences That May Mediate Multiple Protein Interactions in Cancer-Associated Hub Proteins. *PLoS One*. 11, e0155911.
3. Sircar G, Jana K, Dasgupta A, Saha S and Gupta Bhattacharya S (2016) Epitope Mapping of Rhi o 1 and Generation of a Hypoallergenic Variant: A CANDIDATE MOLECULE FOR FUNGAL ALLERGY VACCINES. *J Biol Chem*. 291, 18016-18029.

Grants-in-Aid Schemes :

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

SCIENTIFIC REPORTS

IV

Molecular Medicine

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

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

Introduction

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

Dr. Kaushik Biswas

Associate Professor

Scientific Report

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 resulted in significant reduction in migration of the tumor cell lines, suggesting a plausible role of GM2 in tumor cell migration *in vitro*. Molecular cloning and over-expression of GM2/GD2- synthase gene in a minimally GM2 expressing cell line, SK-RC-45 resulted in increased GM2 expression and consequent tumor cell migration thereby confirming the pro-migratory role of GM2. Gene expression profiling by DNA microarray analysis of siRNA silenced CCF52 cells displayed a number of differentially expressed genes involved in migration. Validation by western blot analysis confirmed the role of integrin mediated signaling in GM2 mediated tumor cell migration. Data shows that over-expression of select gangliosides like GM2 in tumor cells results in enhanced

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

Publications :

1. Datta A, Jaiswal N, Iliyas H, Debnath S , Biswas K , Kumar D and Bhunia A (2017) Structural and Dynamic Insights into a Glycine-Mediated Short Analogue of a Designed Peptide in Lipopolysaccharide Micelles: Correlation Between Compact Structure and Anti-Endotoxin Activity; *Biochemistry,* 56(9), 1348-62, 2017.
2. Kundu M, Mahata B, Banerjee A, Chakraborty S, Debnath S, S Sinha Roy, Ghosh Z and Biswas K (2016) Ganglioside GM2 mediates tumor cell migration by interacting with integrin and modulating the downstream signaling pathway, *Biochim Biophys Acta-Mol. Cell Res.,* 1863 (7 Pt A). 1472-89.
3. Mahata B and Biswas K (2016) Generation of stable knockout mammalian cells by TALEN-mediated locus specific gene editing; *Methods Mol Biol.,* 1498, 107-120.

Students awarded Ph.D.:

Name of Student (University/ Year)	Title of Thesis
Manjari Kundu (C.U., 2017)	Deciphering the role and elucidating the mechanism of tumor derived gangliosides in tumor cell growth, migration, invasiveness and metastasis

Grants-in-Aid Schemes :

Title of the Scheme	Schemes funded by
A novel role of ganglioside Gm2 in the regulation of the Hippo signaling pathway in tumorigenesis.	DST-SERB

Dr. Tanya Das

Senior Professor

Scientific Reports

A. Understanding the role of cancer stem cell-derived exosomes in inducing T regulatory cells: A mechanistic study

On the forefront of anti-cancer therapy is immunotherapy. It is acknowledged that tumor progression is followed by immune evasion which is materialized by tumors via (i) tolerance induction by the developing tumor, and (ii) resistance to killing by activated immune cells. The regulatory T (Treg) cell lineage is indispensable for induction of T cell tolerance, which is one of the major mechanisms of tumor immune evasion. After tumor growth, expansion of Treg cells suppresses the activity of tumor-specific T effector cells. In fact, tumor progression causes simultaneous increase in the population of regulatory T cells (Tregs), a subset of CD^{4+} T cells, which has the expressions of CD25 and Foxp3, and plays important role in maintaining self-tolerance and modulating immune responses. Given the fact that cancer stem cells (CSCs) secrete high amounts of IL-2 and TGF-β, which may be responsible for the expansion of Tregs, the CSC population present within the tumor mass might play an important role in the induction of Tregs from T helper cells or naïve T cells. Irt is therefore, important to understand the mechanism underlying CSC-induced generation of Treg cells and to hinder the same to ameliorate Treg-induced immune evasion and for ensuring proper immunotherapy. Research by various groups have shown the extensive role of exosomes, which are minute 30-200nm vesicles, playing important role in cell-to-cell communication as they carry various bio-reactive substances like mRNA, miRNA, protein etc. Although cancer cell exosomes have been reported to contribute in tumor-induced immunosuppression, there is hardly any report on the role of such CSC-shed micro-vesicles in Treg cell generation, if any. Our data suggest that conditioned media of breast CSCs generate significantly more Tregs from T helper cells or naïve T cells as compared with non-stem cancer cells. Further work verified the presence of exosomes in the above-mentioned conditioned media of CSCs. Interestingly, CSC-exosomes also showed presence of mRNA of FoxP3, the master regulator of Treg cells. These results indicate the possibility that at the initial stages of Treg cell generation, CSC-exosomes might be directly transferring mRNA of FoxP3 to T helper cells or naïve T cells. Targeting CSC-exosomes may therefore, restrict CSC-induced Treg cell generation and inhibit immune-evasion in future.

B. An approach towards understanding the molecular mechanism underlying the asymmetric division of cancer stem cells: Role of TRIM32

Recent studies demonstrate the presence of a rare quiescent subpopulation of cell within the heterogeneous tumor mass which are solely responsible for developing resistance towards chemotherapy and radio-therapy, eventually causing cancer relapses and distant metastasis. This rare quiescent subpopulation is defined as “tumor-initiating cells” (TICs) or “cancer stem cells” (CSCs). Further studies on CSCs revealed that these cells are also adorned with the potential of self-renewal and multi-lineage differentiation. CSCs are also privileged with the efficient strategy from the normal stem cells to undergo asymmetric cell division (ACD), since this dynamic phenomenon ameliorate their ability to achieve appropriate numbers of cancer stem cells and differentiated cancer cells in a single division within the heterogeneous tumor cell population. But the underlying mechanism behind ACD in human cancer stem cells is still unknown. One of the cell fate determinants is TRIM32 (mouse ortholog of Drosophila Brat and Mei-P26), a member of TRIM-NHL (Tripartite motif) family of proteins that has recently come into the limelight, has been reported to regulate the equilibrium between differentiation and proliferation in normal stem cell lineages. Our results showed that human breast cancer stem cells can undergo asymmetric division in which one of the daughter cells expresses the major stemness factor Oct4, while the other does not (Figure 1). Interestingly, TRIM32 has been found to be highly expressed in non-stem cancer cells but not in CSCs. However, whether TRIM32 is responsible for such asymmetric division is yet to be discovered. After delineation of the up-stream mechanism responsible for induction of ACD in CSCs and the exact role of TRIM32 in the same, attempts will be made to identify any natural or synthetic agent(s) that may upregulate TRIM32 expression in CSCs to further differentiate these CSCs to non-stem cancer thereby sensitizing these resistant cells towards chemo-therapy.

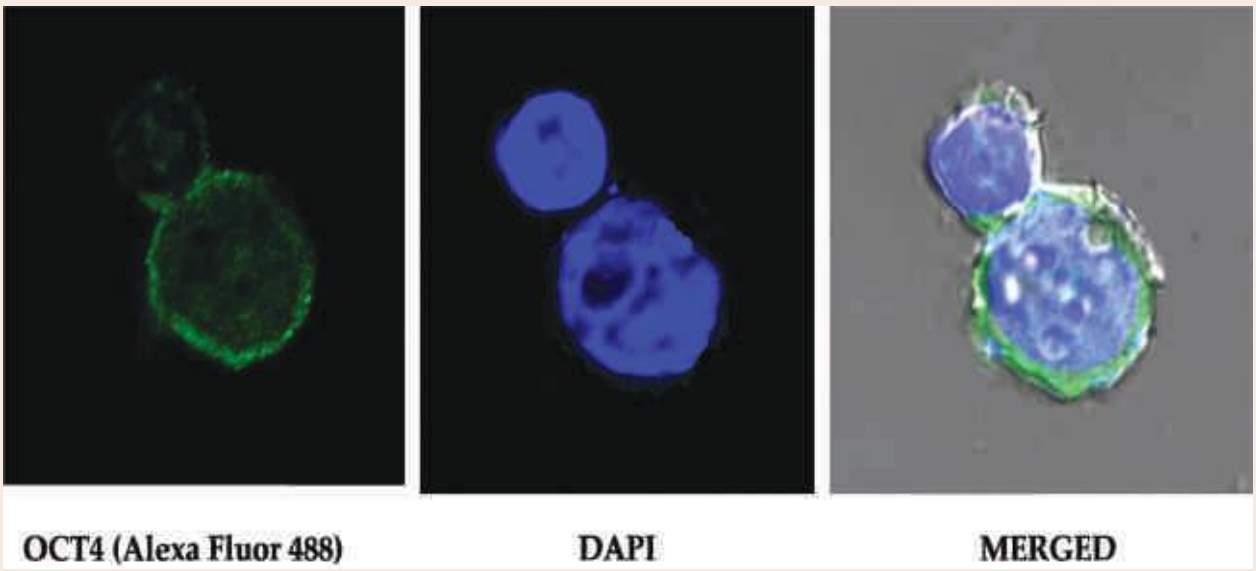


Figure 1. Asymmetric division of cancer stem cells. Indirect Immunofluorescence for Oct4 in human breast cancer stem cell: Left panel represents differential Oct4 (Alexa Fluor 488) distribution in mother and daughter cells; middle panel represents DAPI staining of nucleus; right panel represents the merged image.

C. To manipulate SMAR1 in favor of breast cancer stem cells apoptosis

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. Studies suggest that SMAR1, via p53, is involved in delaying tumor progression in vivo. It acts as a tumor suppressor by repressing CyclinD1 as well as regulating miR 371-373 cluster. We have found that SMAR1 expression diminishes in breast tumor in comparison to normal tissue. SMAR1 expression decreases further in cancer stem cells when compared with its non-stem counterpart. In contrast, when SMAR1 is overexpressed in mammospheres, it leads to a prominent decrease in the expression levels of the stemness factors, e.g., Oct4, Sox2 and Nanog, as well as the drug-resistance pumps, ABCG2, ABCC1 etc. These results indicate the role of SMAR1 in regulation of CSC pluripotency and drug resistance. It will thus be of immense importance to delineate the up-stream mechanism responsible for (i) decrease in SMAR1 expression in CSCs and (ii) its contribution in regulating CSCs so that by modulating SMAR1 expression in CSCs by natural products or FDA-approved drugs, either alone or in combination, can sensitize these resistant cells.

Publications :

1. Banerjee S, Bose D, Chatterjee N, Das S, Chakraborty S, Das T, Saha KD (2016) Attenuated Leishmania induce pro-inflammatory mediators and influence leishmanicidal activity by p38 MAPK dependent phagosome maturation in Leishmania donovani co-infected macrophages. *Sci Rep*. 6:22335. doi: 10.1038/srep22335
2. Basak U, Dutta A, Dutta Chowdhury D, Bhattacharya A, Banerjee S, Khan P and Das T (2017) Deciphering the Cancer Puzzle: Cancer Stem Cells Being the Pivotal Piece. *J Stem Cell Res Transplant*. 4: 1025
3. Chakraborti S, Chakraborty S, Saha S, Manna A, Banerjee S, Adhikary A, Sarwar S, Hazra TK, Das T, 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 Radic Biol Med*. 103:35-47. doi: 10.1016/j.freeradbiomed.2016.11.048.
4. Das A, Dutta A, Paul S, Dutta A, Bhattacharya A, Banerjee S, Dutta Chowdhury D, Basak U, Khan P, Mazumdar D, Das T (2017) Cancer stem cells, their origin and niche: A search for the therapeutic target. *Journal of Stem Cell Research and Medicine*. 2: 2-11
5. Manna A, Banerjee S, Khan P, Bhattacharya A, Das T (2017) Contribution of nuclear events in generation and maintenance of cancer stem cells: revisiting chemo-resistance. *The Nucleus* doi: 10.1007/s13237-017-0193-8
6. *Ray* P, *Guha D, Chakraborty* J, *Banerjee S, Adhikary A, Chakraborty S, Das T and* Sa G (2016) Crocetin exploits p53-induced death domain (PIDD) and FAS-associated death domain (FADD) proteins to induce apoptosis in colorectal cancer. *Scientific Reports* 6:32979. doi: 10.1038/srep32979

Students awarded Ph.D.:

Name of Student (University/ Year)	Title of Thesis
Poulami Khan (C.U., 2017)	A mechanistic approach towards delineating the molecular mechanisms regulating metastasis of non-small cell lung carcinoma
Dr. Taniya Saha (C.U., 2017)	Molecular insights into the mechanism of nuclear-cytoplasmic trafficking : Emerging role of cytoskeletal proteins in cancer.

Grants –in Aid Schemes :

Title of the scheme	Project funded by
Mapping the molecular mechanisms of resistance-to-apoptosis switch over of non small-cell lung carcinoma by curcumin: An approach towards chemo-sensitization	DST
Binning stochastic phenotypic states of cancer cell population in different color box	DBT
Multi-dimensional Research to Enable System Medicine: Acceleration using a Cluster Approach	DBT-Biocluster
(As Co-PI) miR 325: a Distinct miRNA that controls T regulatory cell development and function	DST

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

Delivered invited lectures in the International Conference on angiogenesis and tumor micro-environment in November, 2017 ant Mayo Clinic, USA. Prof. Das also chaired scientific sessions in four International Conferences and delivered invited lecture in the seven International Conferences in India. She participated in two workshops in India.

Seminars / Symposia organized :

Acted as the convenor of the organizing committee of International conference on perspectives of cell signaling and molecular medicine as the part of Centenary Year Celebration of Bose Institute in 2017.

Awards / Honors received :

Selected a Fellow of the National Academy of Sciences (India) in 2016.

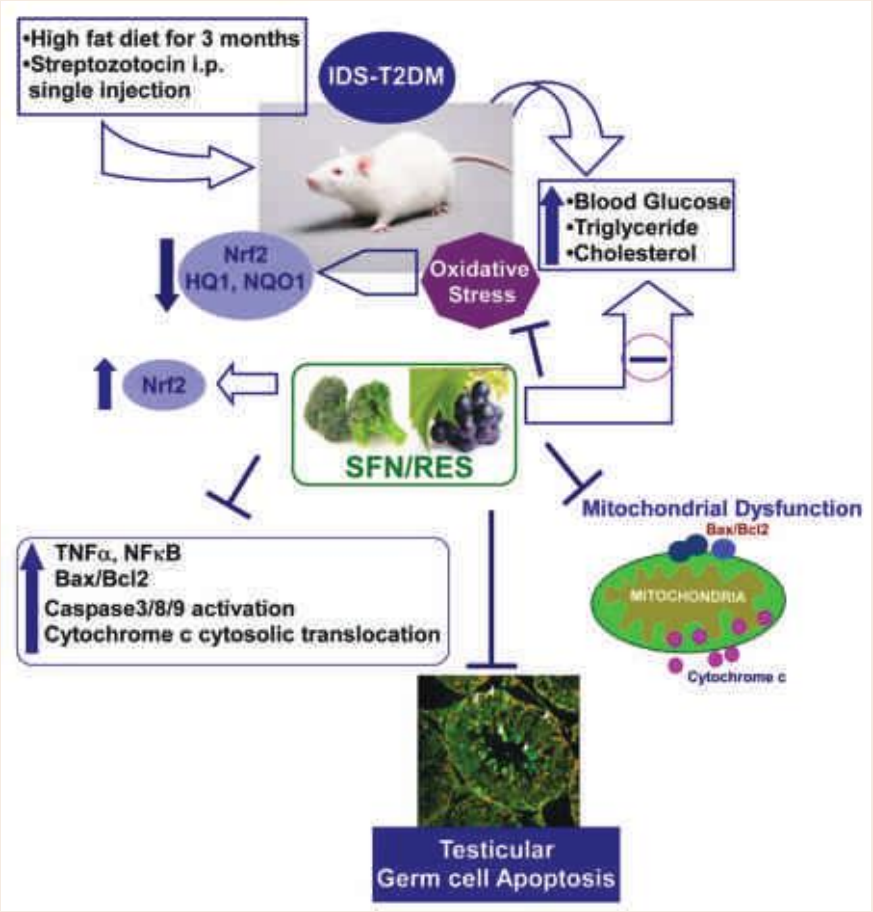
Dr. Kuladip Jana

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)

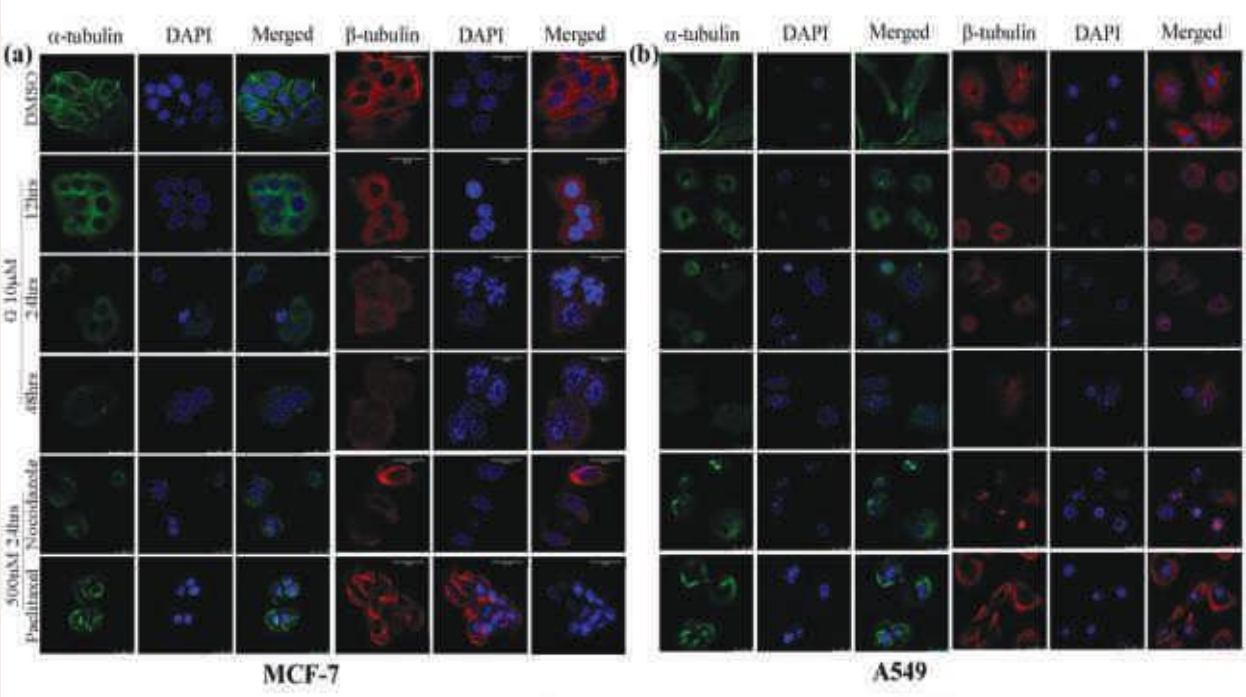
Diabetes-induced testicular cell death is due predominantly to oxidative stress. Nuclear factor (erythroid- derived 2)-like 2 (Nrf2) is an important transcription factor in controlling the anti-oxidative system and is inducible by sulforaphane (SFN) and resveratrol (RES). To test whether SFN/RES prevents 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 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.

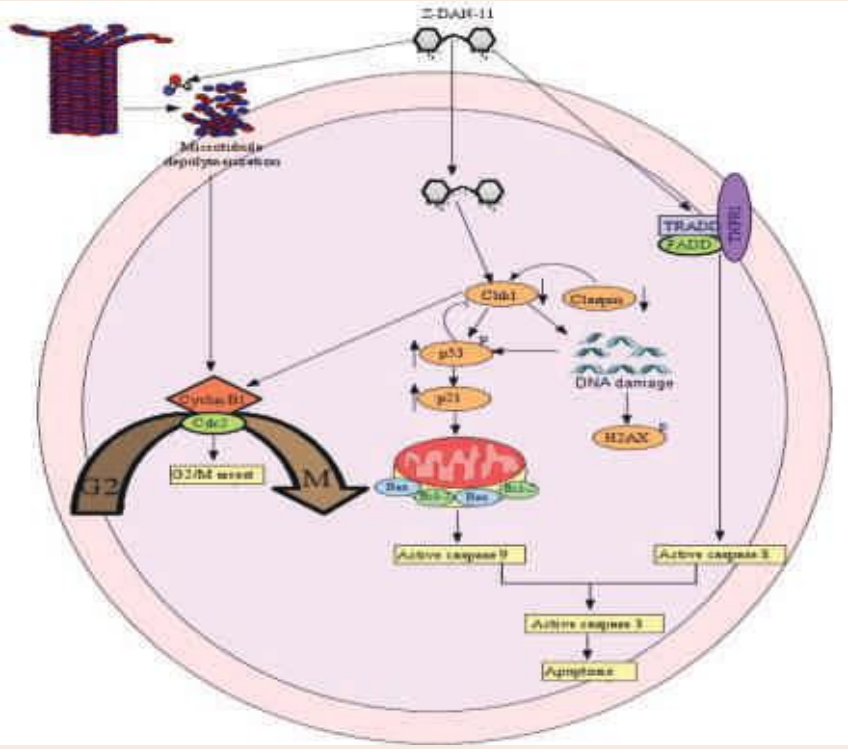
(B) A microtubular dynamics interfering trans-stilbene derivative compound Z-DAN-II drives G2/M arrest, apoptosis and impedes cancer progression: *in collaboration with Prof. Anup K. Misra & Dr. Kaushik Biswas, Division of Molecular Medicine, Bose Institute, Kolkata*

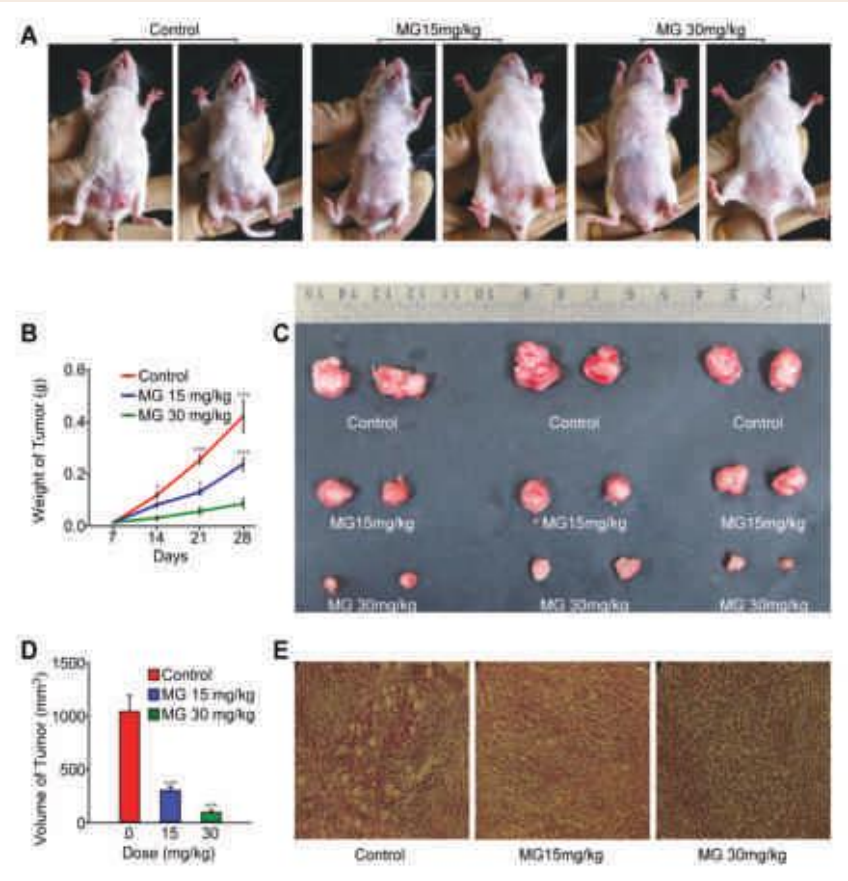
Resveratrol, a *trans* –stilbene polyphenolic compound and its synthetic derivatives have been widely used bioactive molecules due to their remarkable chemopreventive potential. Here, we have identified a novel resveratrol analogue, compound Z-DAN II ((Z)-3-(3, 4-dimethoxyphenyl)-2-(3, 4, 5-trimethoxyphenyl) 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.

C) Induction of Mitochondrial Apoptotic Pathway in Triple Negative Breast Carcinoma Cells by Methylglyoxal via Generation of Reactive Oxygen Species : *in collaboration with Prof Manju Ray, Department of Biophysics, Bose Institute, Kolkata*





Triple negative breast cancer (TNBC) tends to form aggressive tumors associated with high mortality and morbidity which urge the need for development of new therapeutic strategies. Recently the normal metabolite Methylglyoxal (MG) has been documented for its anti-proliferative activity against human breast cancer. However, the mode of action of MG against triple negative breast cancer remains open to question. In our study, we investigated the anticancer activity of MG in MDA MB 231 and 4T1 TNBC cell lines and elucidated the underlying mechanisms. MG dose-dependently caused cell

death, induced apoptosis and generated ROS in both the TNBC cell lines. Furthermore, such effects were attenuated in presence of ROS scavenger N-Acetyl cysteine. MG triggered mitochondrial cytochrome c release in the cytosol and up-regulated Bax while down-regulated anti-apoptotic protein Bcl-2. Additionally, MG treatment down-regulated phospho-akt and inhibited the nuclear translocation of the p65 subunit of NF-κB. MG exhibited a tumor suppressive effect in BALB/c mouse 4T1 breast tumor model as well. This study demonstrated MG as a potent anticancer agent against TNBC both *in vitro* and *in vivo*. The findings will furnish fresh insights into the treatment of this subgroup of breast cancer.

Publications :

1. Banerjee B, Nandi P, Chakraborty S, Raha S, Sen PC, Jana K (2016) Resveratrol ameliorates benzo(a)pyrene induced testicular dysfunction and apoptosis through p38 MAPK/ATF2/iNOS signalling. *The Journal of Nutritional Biochemistry* 34: 17-29.
2. Banerjee A, Sanyal S, Dutta S, Chakraborty P, Das PP, Jana K, Vasudevan M, Das C, Dasgupta D (2016) The plant alkaloid chelerythrine binds to chromatin, alters H3K9Ac and modulates global gene expression. *Journal of Biomolecular Structure and Dynamics*,5: 1-9.
3. Banerjee B, Nandi P, Chakraborty S, Raha S, Sen PC, Jana K (2016) Curcumin and resveratrol synergistically prevent benzo(a)pyrene induced male germ cell apoptosis by modulating MAPKs and p53. *Frontiers in Pharmacology*; 7:245.
4. Dinda, M., Chakraborty, M., Ganguly, D., Dasgupta, U., Dutta, A., Jana, K., Karmakar, P (2016) The water fraction of Calendula officinalis hydroethanol extract stimulates in vitro and in vivo proliferation of dermal fibroblasts in wound healing. *Phytotherapy Research* doi: 10.1002/ptr.5678.
5. Ghosh, R, Pradhan A, Maity P, Jana K, Maiti Choudhury S (2016) Lipid peroxidative damage, alteration in antioxidant status and morphological changes in rat erythrocytes on Lambda-cyhalothrin exposure and its attenuation by taurine. *Toxicology and Environmental Health Sciences*. 8: 315-326.
6. Gucchait A, Jana M, Jana K, Misra AK (2016) Preparation of glycosyl thiourea derivatives from glycosyl azides using sulfamic acid and sodium iodide in one-pot. *Carbohydrate Research*, 434: 107-112.
7. 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* doi: 10.1002/mc.22665.
8. 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. doi.org/10.1371/journal.ppat.1006410.

9. Sirkar G., Jana, K., Dasgupta A., Saha S., Gupta Bhattachrya, S (2016) Epitope mapping of Rhio 1 and Generation of a Hypoallergenic Variant: a Candidate Molecule for Fungal Allergy Vaccines. *The Journal of Biological Chemistry* 291:18016-29.

Dr. Subrata Majumdar

Senior Professor

Scientific Reports

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

Mycobacterium indicus pranii (*MIP*), previously known as *Mycobacterium w,* a saprophytic cultivable mycobacterium, has been found to be effective against leprosy, HIV infection, tuberculosis, Leishmaniasis and lung cancer. Heat killed MIP is reported to boost up the patient's immunity through the induction of a strong pro-inflammatory and CD4+ T helper 1 (Th-1) cells response. As induction of Th1 type of immune response is crucial in overcoming the immuno-suppressive tumor microenvironment, we sought to analyze the immunotherapeutic potential of MIP as an immunomodulator in cervical cancer caused by Human Papilloma Virus (HPV). We found that MIP shows time and dose dependent cytotoxicity on human cervical cancer in HeLa cell line and the killing i may be due to the generation of reactive oxygen species. More work need to be done to decipher the mechanism behind the cytotoxicity.

Early host-parasite interaction during lipid raft mediated entry of *Leishmania donovani* in mouse macrophages: *in collaboration with Suchandra Majumdar (Bhattacharyya), DST-WOS*

During early infection with *Leishmania donovani* promastigotes in macrophages, host cell plasma membrane exhibits significant changes in the cross-talk of lipid raft associated receptors like Toll-like receptor 2 (TLR2), CC-chemokine receptor 5 (CCR5), protein kinase C isotypes (ζ and –δ), ceramide producing enzyme Acid sphingomyelinase (ASMase) . ASMase and PKC zeta are found to be regulated by a feedback mechanism. ASMase mediated ceramide generation also facilitates parasite invasion inside macrophages.

Multidimensional role of a natural triterpinoid compound ursolic acid against visceral leishmaniasis and melanoma cancer: *in collaboration with Prasanta Saini*

Ursolic acid, a natural triterpinoid compound was isolated from the leaf of *Nyctanthes arbortristis* which shows *good* antileishmanial activity in both *in vitro and in vivo study. This compound is very much active at very low concentrations.* We also found that this compound is very active against melanoma cancer cells (B16F10). It inhibits the growth of B16F10 cells *in vitro* in dose and time dependent manner. This compound shows the (Protein kinase C) PKC mediated apoptosis in melanoma cancer cells.

Essential contribution of NOD2 receptor during *Leishmania donovani* infection: *in collaboration with Junaid Jibran Jawed*

Studies were undertaken to analyse the role of intracellular pathogen recognition receptor NOD1/2 during *Leishmania donovani* infection. Our result showed that *Leishmania donovani* exploit NOD2 but not NOD1 pathway during host evasion and establishment of infection. Over expression of NOD2 and subsequent stimulation caused restored host protective immunity and able to induce differential T cell proliferation. Altogether the mechanism of NLR (NOD like receptors) and its participation during experimental visceral leishmaniasis were analysed.

DUSP4 mediated protection against visceral leishmaniasis: *in collaboration with Shabina Parveen*

The DUSP4$^{-/-}$mice have shown their increased susceptibility towards the infection caused by *Toxoplasma gondii* and *Leishmania mexicana*. In order to check the host protective role of DUSP4 in macrophages during Visceral Leishmaniasis, we have silenced DUSP4 with specific siRNA prior to infection within macrophage. We have also analyzed the phosphorylation status of ERK1/2 and p38 MAPK and generation of pro and anti-inflammatory response under DUSP4 knock down condition. We found that Glycyrrhizic Acid, suppresses *L. donovani* infection which is also capable of regulating DUSP4 expression during infection.

Determination of ceramide mediated regulations in melanoma: *in collaboration with Sweta Ghosh*

The undertaken study involved the understanding of mechanism of tumor microenvironment modulations in cancer progression and the key signalling events take place during its metastasis. Along with that we have analysed the specific targeted as a therapeutic approach to decrease metastasis of cancer using anti-cancer agents like cisplatin and *Mw.*

Publications :

1. Banerjee K, Das S, Majumder S, Majumdar S, Biswas J, Choudhuri S M (2017) Modulation of cell death in human colorectal and breast cancer cells through a manganese chelate by involving GSH with intracellular p53 status . *Mol. Cell. Biochem* 427:35–58.
2. Bhattacharjee A, Majumder S, Das S, Ghosh S, Biswas S and Majumdar S (2016) *Leishmania donovani*- induced prostaglandin E2 generation is critically dependent on host toll-like receptor-2-cytosolic phospholilpase A2 signaling. *Infection and Immunity*. Vol. 84(10)
3. Das S, Chowdhury B P, Goswami A, Parveen S, Jawed JJ, Pal N, and Majumdar S (2016) *Mycobacterium indicus parnii* (MIP) mediated host protective intracellular mechanisms against tuberculosis infection: Involvement of TLR-4 mediated siganaling. *Tuberculosis* (Edinb). 2016 Dec: 101: 201-209.doi. 10.1016/ j.tube. 2016.09.2017
4. Jawed JJ, Majumder S, Bandyopadhyay S, Biswas S, Parveen S, Majumdar S (2016) SLA-PGN-primed dendritic cell-based vaccination induces Th17-mediated protectiveimmunity against experimental visceral leishmaniasis: a crucial role of PKCβ.FEMS *Pathogen & Disease*. Jul; 74(5). pii: ftw041. doi: 10.1093/femspd/ftw041. *Epub* 2016.

5. Parveen S, Bandyopadhyay S, Das S, Majumdar S B, Jawed J J, Chowdhury B P, Saha B and Majumdar S (2016) *Mycobacterium indicus parnii* (Mw) mediated protection against visceral leishmaniasis by reciprocal regulation of host dual-specifity phosphatase. *Int. Immunol. Dec*. 28 (12): 588-595.

Students awarded Ph.D :

Students Awarded Ph.D. Name of Student (University/ Year)	Title of Thesis
Kuntal Halder (CU, 2016)	Immunomodulatory role of a novel heat killed *Mycobacterium indicus pranii* (Mw) against solid tumors: Involvement of PKC signalling
Shibali Das (CU, 2016)	A mechanistic approach towards the restoration of host protective immune response during Tuberculosis: Involvement of immunomodulators and signaling mechanisms
Bidisha Paul Chowdhury (C.U., 2017)	A mechanistic insight into arabinosylated lipoarabinomannan (Ara-LAM) mediated modulation of different transcription factors and cytokine signaliing during experimental visceral leishmaniasis

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

Delivered a talk in the Dept. Of Pharmacology at Jadavpur University in Dec., 2016. He has also attended the workshop at University of Tripura in September, 2016.

Seminars / Symposia organized at Bose Institute

Organized International conference on perspectives of cell signaling and molecular medicine as a Secretary and as the part of Centenary Year Celebration of Bose Institute in 2017; (ii) Serving the Institute as a convener of the Centenary Celebration Committee. (iii) Organized a workshop on "One team one Dream" at Falta Farm House of Bose Institute. (iv) XVII All India Congress of Cytology and Genetics & International Symposium on "Exploring Genomes: The New Frontier" Jointly Organized by CSIR-Indian Institute of Chemical Biology and Archana Sharma Foundation of Calcutta, from December 22 - 24, 2016.

Awards / Honors received :

(i) Selected as a visiting fellow of the University of Tripura, 2016 September (ii) received an honour from NASI, WB for his talk on Tobacco use in August, 2016.

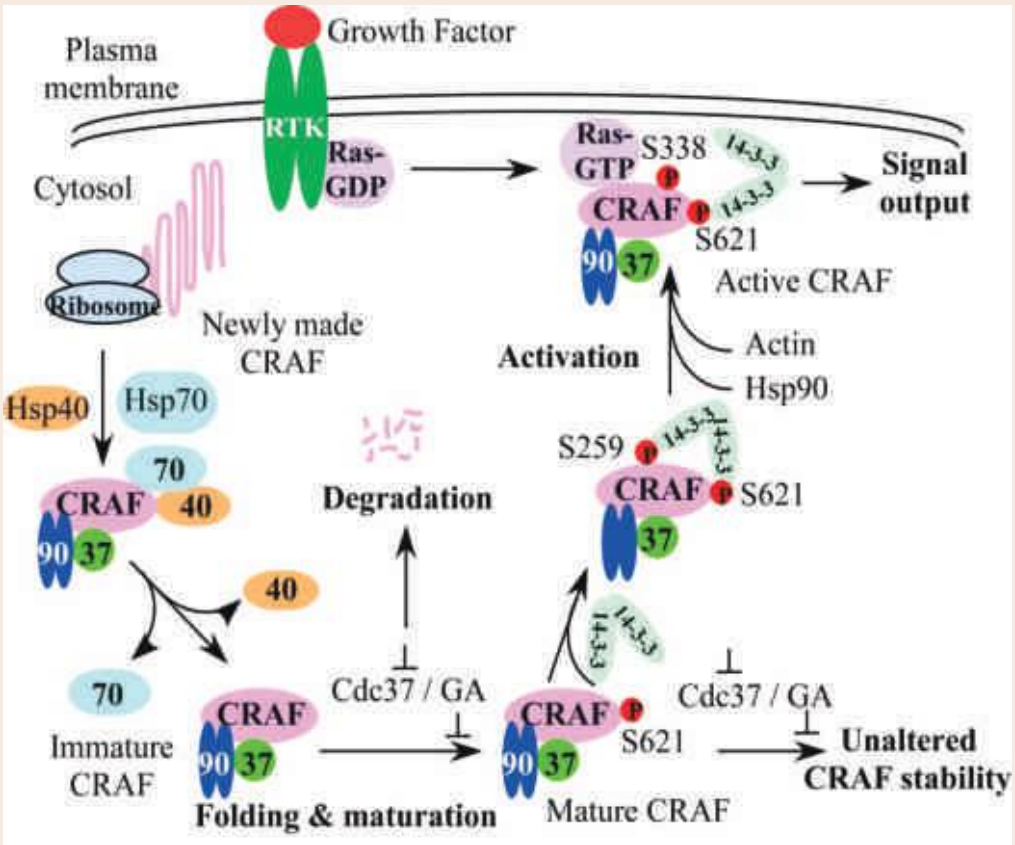
Dr. Atin Kumar Mandal

Associate Professor

Scientific Reports

Heat Shock Protein 90 (Hsp90) dependent regulation of CRAF kinase activity

Mammalian CRAF, unlike its counterpart BRAF requires continuous chaperoning by Hsp90 for its stability and activity. But the underneath reason for continuous dependence on Hsp90 is not clear. Using both yeast and mammalian cell culture we find that chaperones Hsp90 and Cdc37 aid in maturation of CRAF by assisting its autophosphorylation which is essential for CRAF stability and activity. Disruption of any of these two chaperones by genetic impairment or chemical inhibitors leads to impairment of CRAF autophosphorylation and hence accelerates CRAF degradation. Surprisingly, Hsp90 is not dissociated from CRAF in presence of Hsp90 inhibitor, geldanamycin. Interestingly, Hsp90 or Cdc37 inhibition does not have any effect on CRAF when protein synthesis



was blocked. This result suggests that folded CRAF is insensitive to Hsp90 or Cdc37 inhibition. However, physical association with Hsp90 is imperative for CRAF functioning. We find that over-expression of Hsp90 upregulates MAPK pathway by activating CRAF kinase. Co-

immunoprecipitation shows increased Hsp90 binding with CRAF when cellular Hsp90 level is upregulated and either in presence of active RAS or EGF stimulation. Surprisingly, this enhanced Hsp90 binding during stimulation facilitates actin recruitment, but not tubulin to CRAF that drives CRAF translocation to membrane for efficient RAS-CRAF association. This function of Hsp90 does not require its ATPase activity. Thus, our finding establishes the bipartite role of Hsp90 that helps CRAF maturation during folding and actin recruitment to CRAF during mitogenic stimulation for efficient interaction with RAS and downstream signaling.

Exploring the triage decision capacity of Heat Shock Protein 70 (Hsp70) in determining the fate of misfolded proteins

Stress generates misfolded proteins in cell. Cellular protein quality control machinery maintains the homeostasis by refolding of the damaged proteins, degradation by the proteasome or sequestered into specified compartments. Among the chaperones Hsp70 plays a crucial role in deciding the fate of the damaged proteins. Using an in vivo refolding assay system 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 insoluble inclusion (IPOD) when placed at non-permissive temperature (37ºC). The refolding of damaged proteins requires Hsp70's ATPase activity. In addition, we found that J-protein, Ydj1 that catalyzes Hsp70's ATPase activity facilitates refolding of the damaged proteins even at the non-permissive temperature, but in an Hsp70 dependent manner. In contrast, Nucleotide exchange factors (NEFs) have differential behaviours. Sse1 assists Hsp70 in refolding of damaged proteins, whereas overexpression of Fes1 promotes degradation even at refolding condition. Interestingly, Sse1 assists Hsp70 in degradation of protein at physiological condition or Hsp90 inhibition, but Fes1 works during heat stress. Sse1 co-localizes with Juxta-nuclear inclusion (JUNQ) and clears JUNQ inclusion as evident by the Time lapse microscopic study. In contrast, Fes1 co-localizes with 'stress foci' and facilitates clearing of stress foci generated by heat stress. Mutational study showed that the functional role of Sse1/Fes1 in clearance of misfolded proteins/aggregates requires active assistance of Hsp70.

Publications :

1. Mitra, S., Ghosh, B., Gayen, N., Roy, J. and Mandal, A K. (2016) Bipartite role of Hsp90 keeps CRAF poised for activation. *Journal of Biological Chemistry*, 291, 47, 24579-24593.
2. Ratha BN, Ghosh A, Brender JR, Gayen N, Ilyas H, Neeraja C, Das KP, Mandal AK, and Bhunia A. (2016) Inhibition of Insulin Amyloid Fibrillation by a Novel Amphipathic Heptapeptide: Mechanistic Details Studied by Spectroscopy in Combination with Microscopy. *Journal of Biological Chemistry*, 291, 45, 23545-23556.

Grant-in-Aid Schemes :

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

Dr. Nripendranath Mandal

Professor

Scientific Reports

Objectives :

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

Achievements from Marine Biotechnology research :

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

Giant black tiger shrimp, *Penaeus monodon* (Fabricius) 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. Up till now, four DNA markers (442 bp, 236 bp and 71 bp microsatellite DNA marker, 457 bp RAPD-SCAR DNA marker) had been reported in *P. monodon* to identify the disease-resistant shrimp. Recently, 848 bp, 773 bp, 299 bp and 262 bp had been identified in *P. monodon* to recognize the disease susceptible / resistant population. These DNA markers were sequenced and found to be novel and thus were submitted to NCBI nucleotide database. Post challenge data showed that the rate of mortality among WSSV susceptible shrimps were significantly higher than the WSSV resistant shrimps. The quantitative real-time PCR data also suggested that $\sim 10^3$ fold higher WSSV propagation among disease susceptible population than disease resistant population.

Achievements from Medical Biotechnology research:

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

Liver, the largest glandular organ in the body, plays a dynamic role in metabolism, bio-transformation of proteins, carbohydrates, lipids and also detoxification of different endogenous and exogenous xenobiotics and drugs. Iron being an imperative element in countless biological mechanisms in a human body when found in excess, use to trigger the overproduction of various free radicals which are not always effectively normalized by the internal antioxidant defense machinery, thereby causing oxidative stress induced disorders. No cost effective drug prevails in the market which could efficiently cure the iron overload induced diseases without casting any side effects. So, our approach in the Medical Biotechnology research is to develop some orally administrable medicine from natural resources for 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, the bark of *Spondia spinnata* was found to be a promising source of iron-chelating drugs. Recently we have investigated the activity of Gallic Acid and Methyl Gallate along with a glycoside rich fraction, all isolated from *Spondias pinnata* for possible activities of ameliorating iron-overloaded toxicity in mice liver. We have found that all three of them, not only show similar potential activities like the contemporary drug desirox in ameliorating iron-overloaded toxicity in mice liver by effectively scavenging free radicals and iron, but also are potential candidates for a better and safer drug.

Cancer is one of the dreaded diseases in the present global scenario with millions of incidences of affected patients and associated deaths. Flow cytometric and Western blot studies proposed that 70% methanol extract of Euglena tuba (ETME) effectively inhibits the growth of lung cancer (A549) and breast cancer (MCF-7) cells without hampering the normal cells (WI-38). ETME induces the apoptosis and suppresses metastasis including cell migration and cell invasion through the elevation of intracellular ROS levels following suppression of MAPK pathway in both the cells. Previously we have found convincing evidences related to potent antioxidant and anticancer efficacies of *Clerodendrum viscosum* leaves and the fruits of *Terminalia belerica.* Recently, we have successfully determined the active fractions isolated from the above sources, responsible for their activities.

Herbal medicine is indeed an ever evolving field of research, but in the present times it has become important to understand how much exposure and efforts have been given towards this field globally and what are the qualities and feasibilities of the actual outcomes of the studies world-wide. To duly understand this, we have conducted a detailed scientometric analyses by deeply investigated the output from research publications, followed by the contribution from various countries, research institutes, authors, scientific journals and areas of research. The results are pretty encouraging and would help other scientists to channelize their research related to herbal medicine accordingly.

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) an Ir (III) complexes for their antiproliferative activities against cancers of different origins. This year we have explored a series of Pd-based supramolecules and have found that they showed selective activities against brain carcinoma (U87) 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 :

1. Basu T, Mallik A and Mandal N (2017) Evolving importance of anticancer research using herbal medicine: A scientometric analysis. *Scientometrics*, DOI 10.1007/s11192-016-2223-8 (Impact factor: 2.084)

2. Basu T, Panja S, Ghate N B, Chaudhuri D and Mandal N (2017) Antioxidant and antiproliferative effects of different solvent fractions from *Terminalia belerica* Roxb. fruit on various cancer cells. *Cytotechnology* 69:201–216 DOI 10.1007/s10616-016-0051-6 (Impact factor: 1.864)

3. Chaudhuri D, Ghate N B, Panja S, Basu, T, Shendge A K and Mandal N (2016) Glycoside rich fraction from *Spondias pinnata* bark ameliorate iron overload induced oxidative stress and hepatic damage in Swiss albino mice. *BMC Complementary and Alternative Medicine* 16: 262. DOI 10.1186/s12906-016-1244-4 (Impact factor: 2.94)

4. Chaudhuri D, Ghate N B, Panja S, and Mandal N (2016) Role of phenolics from *Spondias pinnata* bark in amelioration of iron overload induced hepatic damage in Swiss albino mice. *BMC Pharmacology and Toxicology* 17: 34. DOI 10.1186/s40360-016-0077-6 (Impact factor: 2.03)

5. Gupta G, Das A, Park K C, Tron A, Kim H, Mun J, Mandal N, Chi K W, Lee C Y (2017) Self - assembled novel BODIPY - based Pd supramolecules and their cellular localization. *Inorganic Chemistry* DOI: 10.1021/acs.inorgchem.7b00260 (Impact factor: 4.820)

6. Panja S, Ghate N B and Mandal N (2016) A microalga, *Euglena tuba* induces apoptosis and suppresses metastasis in human lung and breast carcinoma cells through ROS-mediated regulation of MAPKs. *Cancer Cell International* 16: 51. DOI: 10.1186/s12935-016-0330-5 (Impact factor: 2.884)

Students awarded Ph.D.:

Name of the student (University/Year)	Title of the thesis
Sourav Dutta (C.U., 2016)	Study on the Molecular Understanding of Disease Resistance or Susceptibility by Developed DNA Markers in Giant Black Tiger Shrimp
Nikhil Baban Ghate (C.U., 2016)	Study of Anticancer And Anti-Inflammatory Properties of Indigenous Natural Resources
Usri Chakrabarty (C.U., 2016)	Development and Characterization of DNA Markers to Identify Disease Resistant Population of *Penaeus monodon* for Disease Free Shrimp Aquaculture
Ajoy Mallik (C.U., 2016)	Study on The Research Scenario of White Spot Disease and Importance of Biomarker in the Disease Prevention of Marine Shrimp
Dipankar Chaudhury (C.U., 2016)	Isolation and Identification of Natural Bioactive Antioxidant and Anticancer Compounds In *Spondias pinnata*

Grants-in-Aid Schemes :

Title of the Scheme	Schemes funded by
Molecular characterization of developed DNA markers linked to disease resistance/ susceptibility in giant black tiger shrimp, *Penaeus monodon*"	DST-SERB
"Identification and characterization of micro RNAs (miRNAs) in *Penaeusmonodon*"	DBT

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

(I) Attended the 3rd International Symposium on "Perspective of Cell Signaling and Molecular Medicine" held on January 8 – 10, 2017 at Bose Institute organized by Division of Molecular Medicine, Bose Institute, Kolkata, India. (ii) Delivered a lecture on "Burden & Risk of Non communicable diseases among Asian Indian population: An age old practice for their remedies using traditional medicine" as a Resource Person at the Refresher Course in Behavioural Sciences on the theme 'Theories and Practices in Anthropology and other Behavioural Sciences' during February 02 – 22, 2017 organized by Dept. of Anthropology, University of Calcutta, February 17, 2017. (iii) Served as a member of executive committee and refreshment committee in 3rd International Symposium on "Perspective of Cell Signaling and Molecular Medicine" held on January 8 – 10, 2017 at Bose Institute organized by Division of Molecular Medicine, Bose Institute, Kolkata, India

Social Relevance :

Dr. 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 bio-markers 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 active principles from the bark of *Spondias pinnata* 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 palladium complexes to selectively kill brain 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.

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. Bhaumik I, Misra A Kumar (2017) Convergent Synthesis of the Tetrasaccharide Repeating Unit of the *O*-Polysaccharide of *Salmonella enterica* O41, *ChemistrySelect 2*, 3065-3067.
2. Bhaumik I, Misra A Kumar (2017) Concise Synthesis of a Pentasaccharide Repeating Unit Corresponding to the O-Antigen of Salmonella EntericaO51, *ChemistrySelect 2*, 937-939.
3. Bhaumik I, Misra A Kumar (2016) Expedient synthesis of the pentasaccharide repeatingunit of the O-antigen of *Escherichia coli* O86and its conformational analysis *Glycoconj J.,* 33, 887-896.
4. Chakraborty S, Ghosh S, Banerjee B, Santra A , Adhikary A, Misra A K, Sen P C (2016), Phemindole, a synthetic di-indole derivative maneuvers the store operated calcium entry (SOCE) to induce potent anti-carcinogenic activity in human triple negative breast cancer cells *Frontiers in Pharmacology* ,7, 114/1-114/21.
5. Chakraborty S , Ghosh S, Banerjee B, Santra A, Bhat J, Adhikary A , Chatterjee S, Misra A K , Sen P C (2016) Mephebrindole, a synthetic indole analog coordinates the crosstalk between p38MAPK and eIF2α/ATF4/CHOP signalling pathways for induction of apoptosis in human breast carcinoma cells, *Apoptosis* 21,1106-1124.
6. Ghosh T, Si A, Misra A Kumar (2017) Facile Transformation of Nitriles into Thioamides: Application to C-Glycosyl Nitrile Derivatives, *Chemistry Select 2*, 1366 -69.
7. Gucchait A , Jana M , Jana K , Misra A Kumar (2016) Preparation of glycosyl thiourea derivatives from glycosyl azides using sulfamic acid and sodium iodide in one-pot *Carbohydrate Research* 434, 107-112.
8. Jana M, Ghosh A, Santra A, Kar R Kumar , Misra A Kumar, Bhunia A (2017) Synthesis of novel muramic acid derivatives and their interaction with lysozyme: Action of lysozyme revisited, *Journal of Colloid and Interface Science*, 498, 395-404.
9. Roy C, Alam M , Mandal S, Haldar P K, Bhattacharya S, Mukherjee T, Roy R., Rameez M J, Misra Anup K, Chakraborty R., Nanda A K, Mukhopadhyay S K, Ghosh W (2016) Global Association between Thermophilicity and Vancomycin Susceptibility in Bacteria, *Front. Microbiol.*, 7:412.

10. Si A, Misra A Kumar (2017) Facile synthesis of a rare sugar intermediate: D-gulopyranosyl cyanide. *Trends Carbohydr. Res. 9*, 63 - 66.

11. Si A, Misra A Kumar (2016) Synthesis of a pentasaccharide repeating unit corresponding to the cell wall O-antigen of Escherichia coli O59 using iterative glycosylations in one pot *Tetrahedron* 72, 4435-4441.

Students awarded Ph.D. :

Name of the student (University/Year)	Title of the thesis
Debashis Dhara (C.U., 2017)	Synthesis of oligosaccharide repeating units of the bacterial cell wall polysaccharides
Tamashree Ghosh (C.U. 2016)	Synthesis of complex oligosaccharides of bacterial origin

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.	SERB, New Delhi
Synthesis of oligosaccharide fragments corresponding to *Salmonella* strains and their use in the preparation of glycoconjugate derivatives.	CSIR

Dr. Mahadeb Pal

Professor

Scientific Reports

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

India is a rich source of plants with unique medicinal values. Plant extract containing various medicinal values have been known and methodically in use in various branches of traditional medicine. We have been carrying out projects to screen plant extracts for small 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 we have isolated azadiradione, a triterpenoid from methanolic extracts of neem seed that activates HSF1 by direct physical interaction with high spceificity. This compound ameliorates polyQ disease associated toxicity fruit fly.

In parallel we are purifying activities from plant extracts carefully selected by literature study specific to a particular type of cancer such as colon cancer or prostate cancer. The project is progressing towards identifying mode of action which include targeting signalling network that is specifically modulated by the activity only in the cancer cells but not in the normal cells. We are also close to purification of an activity that sensitises colon cancer cells ~10 fold more than its normal counterpart.

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 overexpression of these proteins such as Hsp70A1A under HS. To this end we found that NF?B cooperates with HSF1 in inducing its expression under HS. Our studies have revealed that NF?B (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

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 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. Detail understanding of this pathway should help obtain an insight into how proteotoxicity connects with inflammation in cells.

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 remains not 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.

Grant-in-Aid Schemes :

Title of the scheme	Project funded by
Understand molecular mechanism of action of a protein chaperone inducer azadiradione and its therapeutic development for Parkinson's disease treatment	DBT
Role of DNA-dependent protein kinase in transcription control in human cells	DBT
Molecular mechanism of HSF1 mediated chromatin remodeling during transcriptional induction of human hsp70 by different stressors	DST

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

I) Delivered an invited talk at "International Symposium on Neurodegenerative Disorders (ISND 2017)" held during March 29 – 30, 2017 at NINHANS, Bengaluru ii) Delivered an invited talk "34th Annual Meeting of Indian Academy of Neurosciences (IAN-2016)" held during October 19 – 21, 2016 at National Brain Research Center, Manesar iii) Attended "5th meeting of the Asian forum of chromosome and chromatin biology" held during January 15 –18, 2015 at JNCSAR, Bangalore.

Publications :

1. Ghosh N, Ali A, Das S, Mandal S C, and Pal M (2016) Chronic Inflammatory Diseases: Progress and Prospect with Herbal Medicine. *Curr Pharm Des*. 22(2): 247-64.
2. 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.

3. Nelson VK, Ali A, Dutta N, Ghosh S, Jana M, Ganguli A, Komaro A, Paul S, Dwivedi V, Chatterjee S, Jana N, Lakhotia SC, Chakrabarti GC, Misra AK, Mandal SC, Pal M (2016) Azadiradione ameliorates polyglutamine expansion disease in *Drosophila* by potentiating DNA binding activity of heat shock factor 1, *Oncotarget*, vol 7, no 48, p 78281.

4. 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

Dr. Gaurisankar Sa

Senior Professor

Scientific Reports

Curcumin channels oncogenic *RAS*-induced pro-proliferative MEK/ERK-signaling toward pro-apoptotic p38MAPK/JNK1-signaling, triggering p53 activation and apoptosis

Oncogenic *RAS* is primarily associated with potent mitogenic ability, the *RAS* mutants also have an apoptogenic activity, which is poorly understood. Therefore, exploring the signaling circuit that shifts RAS-signals from pro-proliferative to death pathways may provide some molecular clues for the missing link between the mitogenic and apoptogenic mechanisms. Here we used a systems biology approach exploiting microarray data and a mathematical model to understand the dual role oncogenic RAS better. This approach unveiled that a curcumin-based intervention shifts the oncogenic RAS-induced MEK/ERK pro-proliferative pathway toward p38MAPK/JNK1 pro-death signaling. This genotoxic-signals resulted in phosphorylation of the p53 at its transactivation domain, for the transcription of BAX and PUMA, required for p53-dependent apoptosis. Our exploration of this novel signaling network indicated that for oncogenic *RAS* to induce transformation, RAS-mediated MEK/ERK hyperactivation needs to dominate over its naturally hardwired anti-tumorigenic functions. In summary, the study delineates hitherto unknown mechanisms by which active RAS mutant act as a signal-switch molecule that can shift signaling from pro-survival to the pro-death circuitry. Our findings highlight potential approaches for tumor control *via* the differential regulation of different MAPK family members, downstream of RAS, and may, therefore, have therapeutic significance.

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

T-regulatory cells are highly upsurge in tumor microenvironment and are known for their pivotal role in tumor immune-evasion. Among the different Treg subsets, CD4$^+$ Treg cells are well characterized whereas the role of CD8$^+$ Tregs in cancer has recently started to crease attention. Here we report an augmentation of TGFβ- and IL10-producing FOXP3-positive immune-suppressive CD8$^+$ Treg cells in breast tumor microenvironment. FOXP3, the lineage-specific transcription

factor, is a dominant regulator of Treg cell development and function. This master regulator is induced preferentially by divergent signalling pathways in $CD4^+$ Treg cells. But how *FOXP3* is induced and maintained in tumor-induced $CD8^+$ Treg cells is the Cinderella of investigation. We observed that RUNX3, a $CD8^+$ T cell lineage-specific transcription factor, binds at the *FOXP3*-promoter to induce its transcription. In addition to promoter activation involvement of *cis*-elements CNS1 and CNS2 in the transcriptional regulation of *FOXP3* was also evident in these cells. TGFβ-induced SMAD3 directly binds to CNS1 region and acts as transcription inducer of *FOXP3*, whereas GATA3 plays a temporal role in the *FOXP3* transcription by differential chromatin modification in CNS regions. In CNS1 region, GATA3 acts as repressor of *FOXP3* transcription in naïve $CD8^+$ cells. Whereas in $CD8^+$ Tregs GATA3 binds directly at CNS2 region and persuaded the maintenance of *FOXP3* transcription. So, the concerted efforts of all these three transcription factors induce and maintain the *FOXP3* transcription in these Treg cells. Therefore, intervention of these transcriptional machineries may have a therapeutic potential in immunotherapy of cancer.

Constraint-driven docking: a logistic docking approach for deriving protein-protein complex structure.

Classical structural methods, such as nuclear magnetic resonance (NMR) and X-ray crystallography often encounter technical difficulties in solving the complex structures. In cases, where structure determination of protein-protein complex with the classical approach seems to be challenging, predictive models can be built based on both experimental input in conjunction with docking studies. Computational docking refers to the modelling or prediction of the three-dimensional structure of a bio-molecular complex, which takes into account the individual protein molecules in their free/unbound form. Constraint-driven docking has been proven to be an efficient approach for docking calculation of unknown protein pairs. Popular protein-protein docking platforms, e.g., HADDOCK (High ambiguity driven bimolecular docking), require the input of atleast one pair of interacting amino acid residues between two complementary proteins in a complex. Among all the docking methods participating in the Critical Assessment of Prediction of Interactions (CAPRI) challenge, HADDOCK is the only true data-driven strategy. Experimental data including site-directed mutagenesis, NMR and mass spectrometry data suggest critical point of protein-protein interaction. These amino acid information, pertaining to anyone/either of the protein/s in a complex, can be incorporated during the docking experiments so as to restrain the docking interface between a pair of proteins. Here we propose that considering known crystal structure (PDB Code: 1YCS), even with a single amino-acid constraint for one of the interacting proteins (p53DBD), constraint-driven docking has been consistently found to be successful. Using varied protein-protein docking algorithms this observation is unfailingly replicated. This validates the constraint-based docking approach in predicting true protein-protein associations and further establishes itself as a robust data-driven docking strategy compared to contemporary structural/docking approaches

Publications :

1. Abir K. ,Panda AK, Bose S, Sarkar T, Roy D, Chakraborty D, Chakraborty, S, Sarkar I & 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.

2. Chakraborty S, Panda AK, Bose S, Roy D, Kajal K, Guha D & 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, 1627.*

3. Panda AK, Chakraborty D, Sarkar I, Khan T & Sa G (2017) New insights into therapeutic activity and anticancer properties of curcumin. *J. Experimental Pharmacology*, 9, 31-45.

4. *Ray* P, *Guha D, Chakraborty* J, *Banerjee S, Adhikary A, Chakraborty S, Das T &* Sa G (2016) Crocetin exploits p53-induced death domain (PIDD) and FAS-associated death domain (FADD) proteins to induce apoptosis in colorectal cancer. *Scientific Reports* 6, 32979; doi: 10.1038/srep32979.

5. *Saha T & Sa Gm (2017)* Constraint-driven docking: a logistic docking approach for deriving protein-protein complex structure. *Protocol Exchange* doi:10.1038/protex.2017.011.

6. Saha T, Guha D, Manna A, Panda AK, Bhat J, Chatterjee S, & Sa G (2016) G-actin guides p53 nuclear transport: potential contribution of monomeric actin in altered localization of mutant p53. *Scientific Reports* 6, 32626; doi: 10.1038/srep32626.

Students awarded Ph.D. :

Name of Student (University/ Year)	Title of Thesis
Taniya Saha (C.U., 2017)	Molecular insights into the mechanism of nuclear-cytoplasmic trafficking: Emerging role of cytoskeletal proteins in cancer.

Grants-in Aid Schemes :

Title of the scheme	Project funded by
As Co-PI	
Mapping the molecular mechanisms of resistance-to-apoptosis switch over of non-small-cell lung carcinoma by curcumin: An approach towards chemo-sensitization	DST
As Co-PI	
Binning stochastic phenotypic states of cancer cell population in different color box	DBT
As PI	
miR 325: a Distinct miRNA that controls T regulatory cell development and function	DST

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

(i) Delivered invited lectures in the International Conference on angiogenesis and tumor micro-environment in November, 2017 ant Mayo Clinic, USA (ii) Chaired scientific sessions and delivered invited talk in 4 *International Conferences in India* (iii) Delivered invited lecture in the 7 International Conferences in India (iv) Participated 2 workshops in India.

Seminars / Symposia organized at Bose Institute :

Organized *International conference on perspectives of cell signaling and molecular medicine as the part of Centenary Year Celebration* of Bose Institute in 2017.

Awards / Honors received :

Awarded the D.P. Burma Memorial Oration Award from Society of Biological Chemist (India) in 2016.

Dr. Parimal C. Sen

Senior Professor

Scientific Reports

Mephebrindole, a synthetic indole analog coordinates the crosstalk between p38MAPK and eIF2**α**/ATF4/CHOP signalling pathways for induction of apoptosis in human breast carcinoma cells: *in collaboration with Dr. Arghya Adhikary, CRNN, Calcutta University, Dr. Subhrangsu Chatterjee, Department of Biophysics, Prof. Anup K. Misra, Division of Molecular Medicine*

The efficacy of cancer chemotherapeutics is limited by side effects resulting from narrow therapeutic windows between the anticancer activity of a drug and its cytotoxicity. Thus identification of small molecules that can selectively target cancer cells has gained major interest. Cancer cells under stress utilize the Unfolded protein response (UPR) as an effective cell adaptation mechanism. The purpose of the UPR is to balance the ER folding environment and calcium homeostasis under stress. If ER stress is prolonged, tumor cells undergo apoptosis. In the present study we demonstrated an 3,30-(Arylmethylene)- bis-1H-indole (AMBI) derivative 3,30-[(4-Methoxyphenyl) methylene]-bis-(5-bromo-1H-indole), named as Mephebrindole (MPB) as an effective anti-cancer agent in breast cancer cells. MPB disrupted calcium homeostasis in MCF7 cells which triggered ER stress development. Detailed evaluations revealed that mephebrindole by activating p38MAPK also regulated GRP78 and eIF2a/ATF4 downstream to promote apoptosis. Studies extended to in vivo allograft mice models revalidated its anti-carcinogenic property thus highlighting the role of MPB as an improved chemotherapeutic option.

Anti-SSTR2 peptide based targeted delivery of potent PLGA encapsulated 3,3´-diindolylmethane nanoparticles through blood brain barrier prevents glioma progression: *in collaboration with Dr. Mrinal K. Ghosh, IICB, Jadavpur*

Current therapy for Glioblastoma is insufficient because of the presence of blood brain barrier. It limits the transport of essential drugs to the tumor sites. To overcome this limitation we strategized the delivery of an anticancer compound 3,3'-diindolylmethane by encapsulation in poly (lactic-co-glycolic acid) nanoparticles. These nanoparticles were tagged with a novel peptide against somatostatin receptor 2 (SSTR2), a potential target in glioma. The nanoformulation (27-87nm) had loading and encapsulation efficiency of 7.2% and 70% respectively. It was successfully internalized inside the glioma cells resulting in apoptosis. Furthermore, an *in vivo* bio-distribution study revealed the selective accumulation of the nanoformulation into rat brain tumor sites by crossing the blood brain barrier. This resulted in abrogation of epidermal growth factor receptor pathway activation in glioma cells. Our novel nanopreparation therefore shows great promise to serve as a template for targeted delivery of other therapeutics in treating GBM

Publications :

1. Banerjee B, Chakraborty S, Raha S, Sen P C and Jana K (2016) Synergistic protective effect of curcumin and resveratrol against benzo(a)pyrene induced apoptosis in male germ cells: role of Akt, MAPKs and p53. *Frontiers in Pharmacology*. doi:10.3389/fphar.2016.00245. Vol. 7.IF = 4.418.
2. Banerjee B, Nandi P , Chakrabarty S, Raha S, Sen P C and Jana K (2016) Resveratrol ameliorates Benzo(a)pyrene induced testicular dysfunction and apoptosis: involvement of p38 MAPK/ATF2/iNOS signaling. *Nutritional Biochemistry*. 34, 17-29. IF = 4.592.
3. Chakraborty S, Ghosh S, Banerjee B, Santra A, Adhikary A, Misra A K, Sen, P C (2016) Phemindole, a synthetic di-indole derivative maneuvers the store operated calcium entry (SOCE) to induce potent anti-carcinogenic activity in human triple negative breast cancer cells. *Frontiers in Pharmacology*. Vol 7 doi: 10.3389/fphar.2016.00114. IF = 4.418.
4. Chakraborty S, Ghosh S, Banerjee B, Santra A, Bhat J, Adhikary A , Chatterjee S , Misra A K and Sen P C (2016) *Mephebrindole, a synthetic indole analog coordinates the crosstalk betweenp38MAPK and eIF2α/ATF4/CHOP signalling pathways for induction of apoptosis in human breast carcinoma. Apoptosis*. 21, 1106-1124. IF = 3.865.

Grants- in- Aid Schemes :

Title of the Scheme	Schemes funded by Project
With Prof. Parames C. Sil (Co-PI) Targeting the miRNA axis with a synthetic small molecule, Nifetepimine to restrict migration of triple negative breast cancer cells.	DST-SERB

Awards/ Honours received :

Editorial Board Member	Global Journal of Nanomedicine
Editorial Board Member	Austin Biochemistry (USA)
Editorial Board Member	Journal of Molecular Medicine & Therapy

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

(i) Delivered talk at Muragachi Gov't College in NASI-Kolkata Chapter Outreach Programme, June 5, 2016; (ii) Delivered invited talk at National Institute Science Education & Research (NISER), Bhubaneswar, September 16, 2016 (iii) Chaired Session in Indo-Brazil Symposium at IICB, Kolkata, September 20, 2016 (iv) Delivered an invited talk at Maulana Abul Kalam Azad University of Technology on March 30, 2017 organized by TEQUIP II.

Dr. Parames C Sil

Senior Professor and Coordinator

Scientific Reports

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

Main objectives :

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

However, special emphasis is placed upon

- Exploring chemical and drug induced mechanisms of cell injury/death (both in vivo and in vitro).
- Understanding the mechanisms of antioxidant potentials of phytochemicals against several pathophysiological conditions like diabetes, colitis etc.
- Targeted drug delivery through different nanoparticles to enhance the efficiency.
- Studies on the signal transduction mechanisms in neuronal cells and tissue in Parkinson's disease and related pathophysiological condition.
- Investigating the anti-cancer potential of different phytochemicals and synthesized derivatives.

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.

Targeted co-delivery of anti-cancer drugs and regulatory gene agents, using nanoparticles, for synergistic anti-cancer effect

Cancer is one of the most fatal diseases and causes millions of cancer-related deaths every year. Although chemotherapy is a treatment of choice for many types of cancers, but its success is often hampered by development of drug resistance after repeated administration of chemotherapeutic drugs. It is known that cancer cells can develop mainly two kinds of cellular defense mechanisms; which include efflux pump-mediated and non-pump-related Multi-drug resistance (MDR), thereby preventing cell death.

We are trying to increase the bioavailability of natural antioxidants and to improve their targeted delivery into tumour tissues and reduce their toxicity on normal tissues by use of nanotechnology drug delivery system. We focus on synthesis of mainly low toxic mesoporous silica nanoparticles which not only overcome the problems of drug delivery but will also enhance the therapeutic efficiency of the drug by its easy surface modification. We have synthesized folic acid (FA) armed mesoporous silica nanoparticles (MSN-FA-Q) loaded with quercetin and then characterized it by DLS, SEM, TEM and FTIR. MTT, confocal microscopy, flow cytometry, scratch assay and immunoblotting were employed to assess the cell viability, cellular uptake, cell cycle arrest, apoptosis, wound healing and the expression levels of different signalling molecules in breast adenocarcinoma cells. Nanoparticle distribution was investigated by using ex vivo optical imaging to assess tumour regression.

Simultaneous delivery, of conventional cytotoxic drugs and therapeutic siRNA targeting the MDR regulatory gene into the same tumor cell, plays a key role to increase the chemotherapeutic efficiency; therefore, search for appropriate nanocarriers for codelivering drugs and siRNA is warranted. We hypothesized that the synthesized tumor targeted nanocarriers co-loaded with

cytotoxic drugs and gene agent will effectively accumulate in the cancer cells and tumor in vivo. This will also facilitate release of the bound drug via the cleavage of acid-labile hydrazone bond in the weakly acidic intracellular compartments and affect the expression of the apoptosis and MDR regulatory genes.

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

Spleen is a secondary lymphoid organ and plays an active role in the immune system by producing various antibodies. Chronic hyperglycemic state in diabetes leads to damage of various organs including spleen due to oxidative stress. Present study has been conducted to explore the role of polyphenolic curcumin on spleen tissue in diabetes. For this purpose adult male Wistar rats were made diabetic by injecting them with a single intraperitoneal dose of streptozotocin (STZ, at a dose of 65 mg/kg body weight). Animals with blood glucose level above 300 mg/dL were considered as diabetic. Consistent with our previous studies we observed reduction in the body weight as well as serum insulin level and increment in the oxidative stress related parameters in the type-1 diabetic model. In addition, damage spleen anatomy with depleted white pulp has also been found in the same group. Investigation of the cellular mechanism for the oxidative stress dependent and inflammation mediated splenic damage in diabetes showed upregulation in the level of different proinflammatory cytokines (TNF-α?, IL-1β and IL-6), chemokine (MCP-1), adhesion molecules (ICAM-1 and VCAM-1) and translocation of transcription factor NF-κB in the nucleus. Activation of the downstream signaling molecules of NF-κB like COX-2 and iNOS were also observed in diabetes. Moreover, upregulation in the expression of phospho-eIF2α, GRP-78, CHOP, calpain-1, caspases (12 and 3) and phospho JNK has been found in case of endoplasmic reticulum (ER) dependent apoptotic death of the spleen cells under hyperglycemic state. However, curcumin at oral dose of 100 mg/kg body weight ameliorate all the changes to a significant extent near to control. This study suggests curcumin provide protection to spleen in diabetes by attenuating the upregulation of various proteins related to inflammation and cell death. Therefore, it could be a probable candidate for the treatment of oxidative stress mediated splenic damage in diabetes. Data of this study is about to publish.

Ameliorative effect of silymarin against thioacetamide induced liver injury

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

silymarin could protect liver cells against TAA exposed cellular damage and oxidative stress and if so, what molecular pathways it utilizes for its protection.

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

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

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

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

Selective anticancer activity of naturally occurring polyphenolic compounds and synthetic derivatives via the induction of oxidative stress

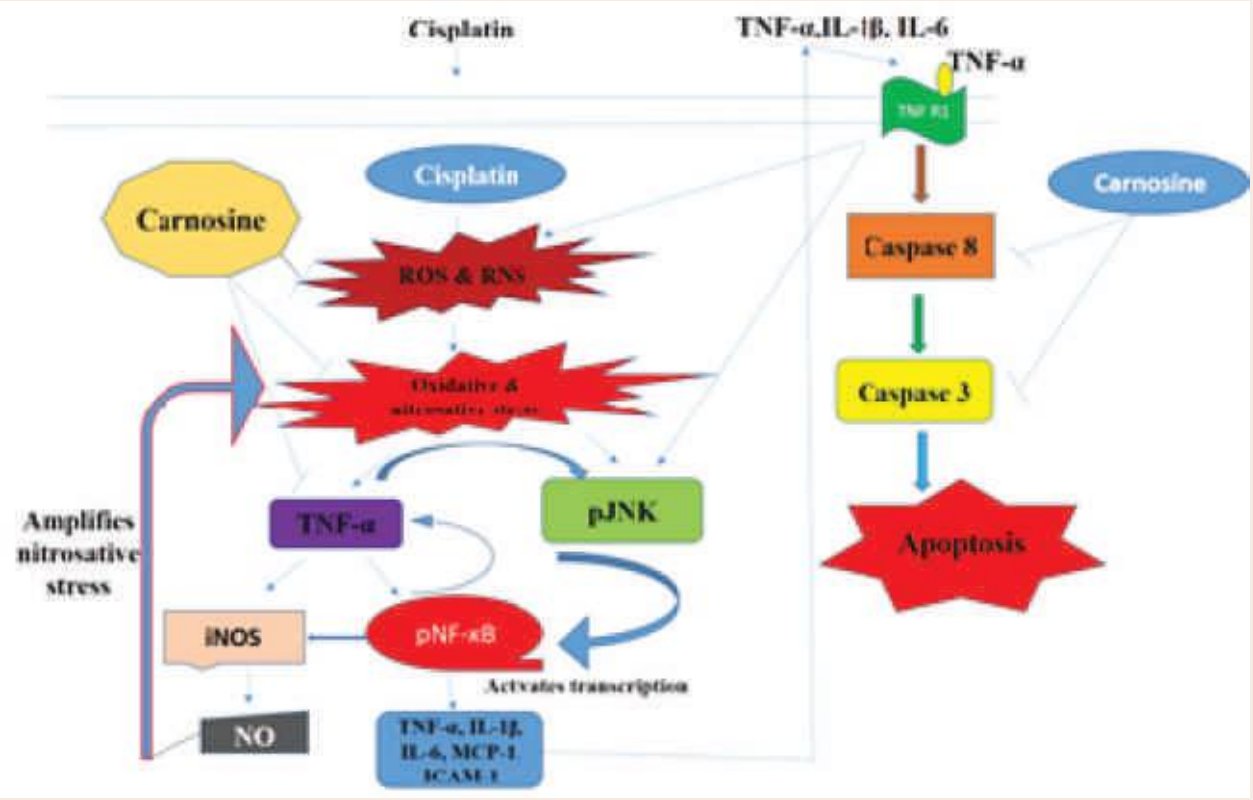
Cancer is one of the leading cause of death in most of the countries. Cancer develops when somatic cells mutate and escape the restraints that normally restrict them in their problematic expansion. Many signaling pathways that are linked to tumorigenesis can also regulate the metabolism of ROS through 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.

Role of carnosine in chemotherapeutic drug induced toxicity of spleen

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



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

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

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 monitered. Finally, histological sections will be analyzed to study the effective protection provided by the selected bioactive molecule.

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

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

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

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

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

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

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

Publications :

1. Bhattacharyya S, Banerjee S, Guha C, Ghosh S, Sil PC (2017) A 35 kDa Phyllanthus niruri protein suppresses indomethacin mediated hepatic impairments: Its role in Hsp70, HO-1, JNKs and Ca 2+ dependent inflammatory pathways. *Food and Chemical Toxicology*.;102:76-92.
2. Ghosh S, Basak P, Dutta S, Chowdhury S, Sil PC (2017) New insights into the ameliorative effects of ferulic acid in pathophysiological conditions. *Food and Chemical Toxicology.*
3. Dutta S, Sadhukhan P, Saha S, Sil PC (2017) Regulation of Oxidative Stress by Different Naturally Occurring Polyphenolic Compounds: An Emerging Anticancer Therapeutic Approach. *Reactive Oxygen Species*. 3(8):81-95.
4. Chowdhury S, Ghosh S, Rashid K, Sil PC (2016) Deciphering the role of ferulic acid against streptozotocin-induced cellular stress in the cardiac tissue of diabetic rats. *Food and Chemical Toxicology* ;97:187-98.
5. Chowdhury S, Sinha K, Banerjee S, Sil PC (2016) Taurine protects cisplatin induced cardiotoxicity by modulating inflammatory and endoplasmic reticulum stress responses. *BioFactors*, 42(6):647-64.
6. Sarkar A, Ghosh S, Chowdhury S, Pandey B, Sil PC (2016) Targeted delivery of quercetin loaded mesoporous silica nanoparticles to the breast cancer cells. *Biochimica et Biophysica Acta (BBA)-General Subjects* 1860(10):2065-2075.
7. Saha S, Sadhukhan P, Sil PC (2016) Mangiferin: A xanthonoid with multipotent antiinflammatory potential. *BioFactors*. 42(5):459-74.
8. Saha S, Rashid K, Sadhukhan P, Agarwal N, Sil PC (2016) Attenuative role of mangiferin in oxidative stress-mediated liver dysfunction in arsenic-intoxicated murines. *Biofactors*. 2016;42(5):515-32.
9. Sadhukhan P, Saha S, Sinha K, Brahmachari G, Sil PC (2016) Selective Pro-Apoptotic Activity of Novel 3, 3'-(Aryl/Alkyl-Methylene) Bis (2-Hydroxynaphthalene-1, 4-Dione) Derivatives on Human Cancer Cells via the Induction of Reactive Oxygen Species. *PloS one.* 2016;11 (7):e0158694.
10. Ghosh S, Sarkar A, Bhattacharyya S, Sil PC (2016) Silymarin protects mouse liver and kidney from thioacetamide induced toxicity by scavenging reactive oxygen species and activating PI3K-Akt pathway. *Frontiers in Pharmacology*. 2016;7.
11. Saha S, Sadhukhan P and Sil PC (2017) Beneficial Upshots of Naturally Occurring Antioxidant Compounds against Neurological Disorders. Neuroprotective Natural Products: Clinical Aspects and Mode of Action, pp.23-56.
12. Rashid K and Sil PC (2016) Identification and Extraction of Antidiabetic Antioxidants From Natural Sources. Discovery and Development of Antidiabetic Agents from Natural Products: Natural Product Drug Discovery, pp.63-112.

3rd International Conference on 'Perspectives of Cell Signaling and Molecular Medicine' held on January 8-10, 2017. Prof. Harvey Lodish, MIT, Boston, USA was presented and delivered 1st Centenary lecture on "Self-renewal of human hematopoietic progenitor cells: From the clinic to the laboratory and back to the clinic: Development of novel therapies for anemias. He also visited Bose Institute Museum.

SCIENTIFIC REPORTS

V

Basic and Applied Microbiology

Participation in Institutional Project for the 12th Five Year Plan (2012-2017)

Dr. Sujoy K. Das Gupta (coordinator), Dr. Joyoti Basu, Dr. Manikuntala Kundu, Dr. Pradeep Parrack, Dr. Tapan Datta, Dr. Subrata Sau, Dr. Srimonti Sarkar, Dr. Abhrajoyoti Ghosh.

Introduction

The objective 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, andunderstanding 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 propagationmechanisms.

Dr. Joyoti Basu

Senior Professor

Scientific Reports

MicroRNA 26a/KLF4 and C/EBP beta dependent signalling regulates *Mycobacterium tuberculosis* (Mtb)-driven macrophage polarization and trafficking of Mtb to lysosomes: *in collaboration with Dr. Manikuntala Kundu, Dr. Zhumur Ghosh, Dr. Kuladip Jana and Umesh Gupta, CIIMOD, Agra*

Global miRNA-mRNA profiling of Mtb-infected macrophages was used as a starting point to identify transcriptional networks involved in regulating the macrophage response to infection. We have uncovered a signalling pathway establishing that the downregulation of miRNA miR26a-5p is inversely correlated to the levels of the transcription factor KLF4. miR-26a targets KLF4. KLF4 inhibits the expression of inducible nitric oxide synthase (iNOS) and augments the expression of

arginase-1 thereby tilting the balance in favour of M2 polarization. At the same time, KLF4 augments expression of the autophagy inhibitor Mcl-1, thereby inhibiting autophagy during infection. Lysosomal trafficking of Mtb is consequently also inhibited. The second transcription factor of our focus, C/EBP beta emerges as another regulator of macrophage polarization. It too augments arginase expression and inhibits iNOS expression. It also augments expression of other markers of M2 polarization such as IL-10. We speculate that KLF4 likely augments expression of the regulator MCPIP which in turn augments transcriptional activity of C/EBP beta, linking the two transcription factors which are the focus of our study. Both these transcription factors emerge as important regulators of the outcome of infection, tilting the balance in favour of survival of the bacterium in the host macrophages during the early hours of infection. Knockdown of either transcription factor, inhibits the survival of Mtb in macrophages.

Publication :

1. Banerjee S K, Kumar M, Alokam R, Sharma A K, Chatterjee A, Kumar R, Sahu S K, Jana K, Singh R, Yogeeswari P, Sriram D, Basu J, Kundu M (2016) Targeting multiple response regulators of Mycobacterium tuberculosis augments the host immune response to infection. *Scientific Reports,* 6: 25851.

Dr. Sujoy K Das Gupta

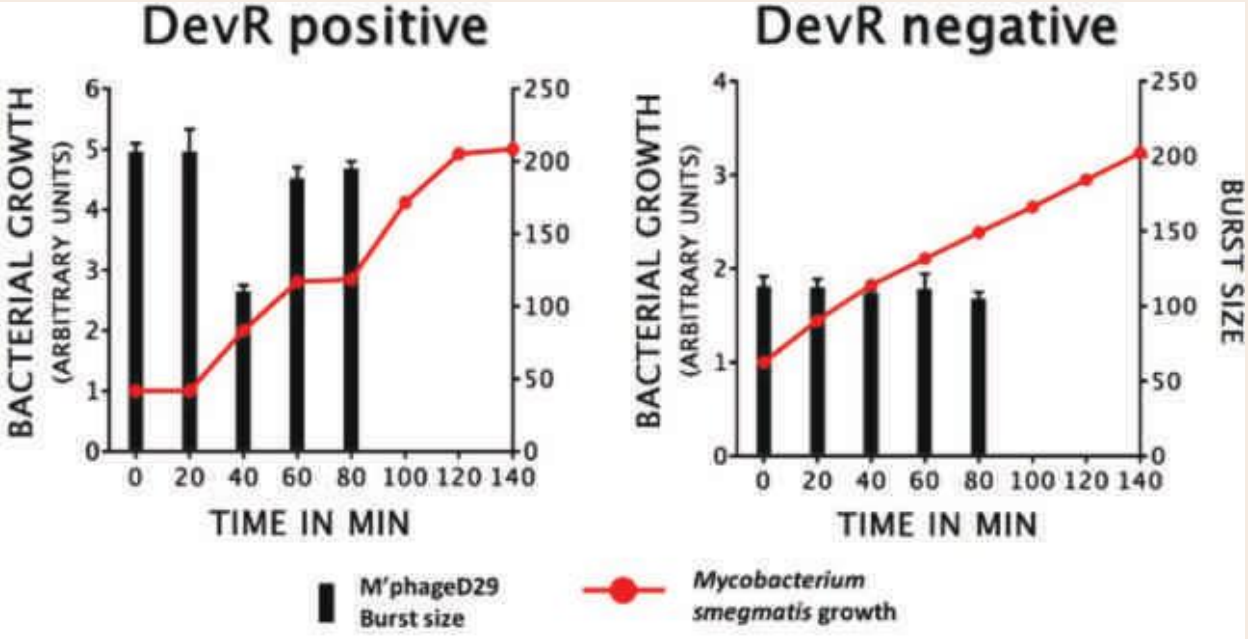
Senior Professor and Coordinator

Scientific Reports

Vitamin C treatment induces synchronization of mycobacterial growth

Vitamin C is known to inhibit mycobacterial growth by acting as a hypoxia inducing agent. We have shown that transient exposure of *Mycobacterium smegmatis* cells to Vitamin C resulted in growth synchronization. Interestingly the phenomenon happened only in cell types that were positive for DevR, the hypoxic response regulator of mycobacteria, but not in the mutants that lacked this function. Growth synchronization induced by Vitamin C also had an impact on the proliferation properties of a phage known as D29, that infects mycobacteria. Burst size of this phage wasfound to be higher when resting *M. smegmatis*cells were infected as compared to when the same was done using the dividing ones. The results indicate that the mycobacterial hypoxia response regulator DevR, also known as DosR, not only acts by controlling the expression of hypoxia responsive genes, as is currently believed, but also by influencing DNA replication and the growth cycle of mycobacteria.

Growth kinetics (red lines) of *M. smegmatis*, either wild type (DevR positive) or a *devR* mutant (DevR negative), exposed to Vitamin C for 1 hour, prior to commencement of aerobic growth. The black bars represent phage D29 burst sizes at different stages of growth of the host, *M. smegmatis*.



Publication:

1. Kirtania P, Ghosh S, Bhawsinghka N, Chakladar M, Das Gupta SK (2016) Vitamin C induced DevR-dependent synchronization of *Mycobacterium smegmatis* growth and its effect on the proliferation of mycobacteriophage D29. *FEMS Microbiol Lett*. 363 (11): fnw097.

Students awarded Ph.D :

Name of the Student	Title of Thesis
Sourabh Samaddar (C.U., 2016)	Understanding the dynamics of mycobacteriophage-mycobacteria interaction using mycobacteriophage D29-*Mycobacterium smegmatis* as the model system

Grants-in-Aid Schemes :

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

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

Delivered a seminar talk on the topic "Mycobacteriophage based platforms to discover novel drug targets for mycobacteria"at the symposium "Meeting on Molecular Microbiology" held at CDFD Hyderabad on the February 10 – 11, 2017.

Seminars / Symposia organized at Bose Institute:

The members of the program V organized a one-day symposium on the topic “The world of microbes – pathogenesis, environment and evolution” on October 17, 2016.

Dr. Tapan K. Dutta

Professor

Scientific Reports

Biochemical and molecular characterization of bacterial catabolic potential and evaluation of regulatory mechanism of the catabolic operons

Isolation and characterization of bacteria belonging to the genera *Sphingobium*, *Burkholderia*, *Cupriavidus* etc, are being used for the assimilation of various pollutants including PAHs and diverse substituted aromatics like hydroxynaphthoic acids, nitrobenzoic acids, hydroxyl/aminonitriles, estrogenic phthalates etc.

The genetic characterization of the novel 2-hydroxy-1-naphthoic acid (2H1NA) degrading *hnd* operon in *Burkholderia* sp. BC1, revealed the presence of a unique non-oxidative decarboxylase (HndA) of the amidohydrolase-2 family that carries forward the primary decarboxylation step in the degradation of 2H1NA. Alongwith functional characterization of the enzyme, a three dimensional structural model has been constructed to identify the important amino acid residues responsible for substrate binding and catalysis (Fig. 1). Site directed mutagenesis studies established the importance of the critical amino acid residues in the decarboxylation of 2H1NA. The study showed that the strict substrate specificity of the metallo-enzyme towards 2H1NA and its unique sequence reinforce its position into the metallo-dependent hydrolase superfamily as a unique member.

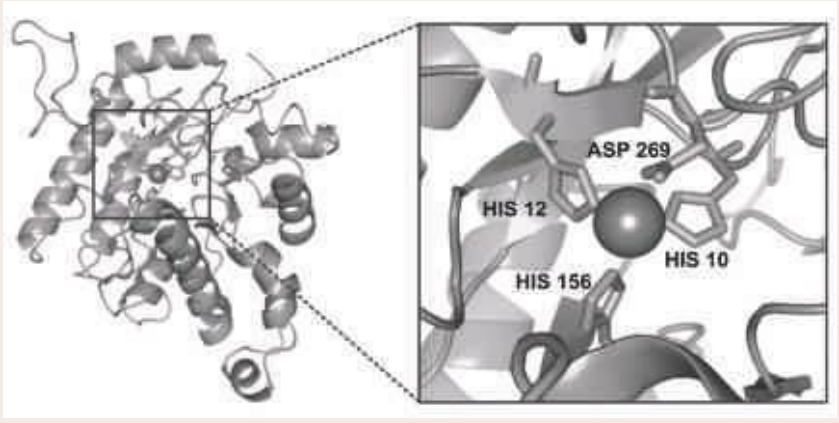


Fig 1. Schematic representation of the structural model of HndA showing the enzyme active site. Inset shows the metal coordinating residues His10, His12, His156 and Asp269.

Again, comprehensive biochemical and genetic analyses together with pathway engineering resulted in the development of a genetically modified *Cupravidus* sp. strain ST-14 capable of assimilating all the three isomers of mononitrobenzoic acids. Apart from that, it was observed that

strain ST-14 can utilize a wide array of toxic anthropogenic and lignin derived phenylalkanoic acids. Standard biochemical analyses showed that all the isomers of hydroxyphenylacetic acid were degraded via homogentisic acid as pathway intermediate. Moreover, biochemical pathways had been revealed for the degradation of hydroxyphenylpropionic acid isomers. Interestingly, unlike the reported *meta* cleavage of 2,3-dihydroxyphenylpropionic acid in the degradation of 3-hydroxyphenylpropionic acid, a different ring-cleavage pathway was revealed in strain ST-14, reinforcing the presence of a novel pathway. Enzymatic analysis as well as proteomic approaches has been in progress to identify and characterize the associated novel enzymes.

Based on the biochemical and genomic details of the degradation of nitrobenzoic acids in *Cupriavidus* sp. strain ST-14, a mechanistic model had been elucidated to show the interplay among the promoter-operator sequence, regulator protein and the inducer 2-nitrobenzoic acid (2NBA) in the expression of the 2NBA degrading *onb* structural genes. This information had also been exploited to construct a bioreporter strain (Fig. 2) that can only sense the presence of 2NBA specifically among the tested mononitrobenzoate isomers (2NBA, 3NBA and 4NBA) and its structurally homologous compounds.

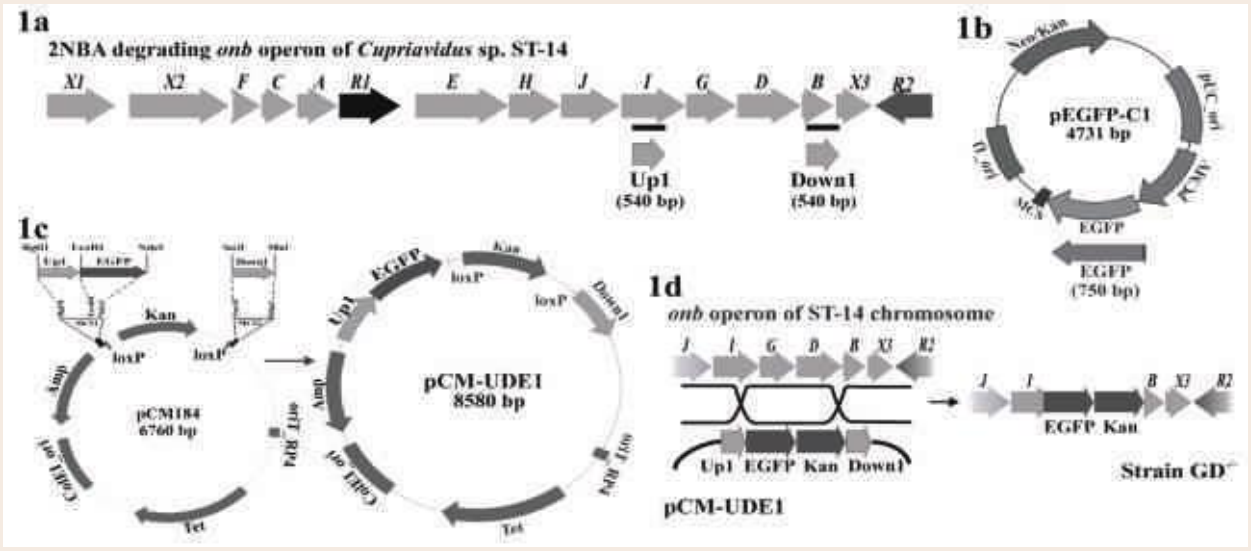


Fig 2. Schematic diagram showing the mechanism of reporter gene (EGFP) incorporation into bacterial chromosome to construct bioreporter strain.

In another study, attempts have been made to elucidate the regulation mechanism of the degradation of polycyclic aromatic hydrocarbons in *Sphingobium* sp. strain PNB, a versatile aromatic degrader. Genetic characterization revealed an apparent scattered genomic architecture of relevant catabolic genes. The regulatory mechanism of the scattered catabolic genes involved in the degradation pathways of phenanthrene, biphenyl, naphthalene and their metabolic intermediates are being investigated based on biochemical analyses as well as real time PCR studies.

Biological treatment of pollutants-contaminated hyper saline environments is not possible with conventional microorganisms because they are incapable to function efficiently at salinities that of seawater or above. While screening for halophiles that can degrade various aromatics at salinities ranging from 4% and above, a number of degraders have been isolated. Further attempts have been

made to characterize their metabolic pathways both at the biochemical and molecular levels with an intention to explore the molecular mechanism of pathways of degradation and evolution of the key catabolic enzymes.

Publications :

1. Basu S, Pal Chowdhury P, Deb S, Dutta TK (2016) Biochemical and molecular characterization of the degradation pathways of 2- and 4-nitrobenzoates in *Cupriavidus* sp. strain ST-14 and construction of a recombinant strain ST-14::3NBA capable of degrading 3-nitrobenzoate. *Appl Environ Microbiol,* 82, 4253–4263.
2. Pal Chowdhury P, Basu S, Dutta A, Dutta TK (2016) Functional characterization of a novel member of the amidohydrolase 2 protein family, 2-hydroxy-1-naphthoic acid nonoxidative decarboxylase from *Burkholderia* sp. strain BC1. *J Bacteriol, 198, 1755-1763.*

Grants-in-Aid Schemes :

Title of the Scheme	Schemes funded by
Hydrogenogenic carbon monoxide conversion under mesophilic condition using anaerobic granular sludge for biodesulphurization	DBT

Dr. Abhrajyoti Ghosh

Assistant Professor and DST-Ramanujan Fellow

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 in regard with different molecular chaperones. In addition, our recent venture is to study the components of archaeal defense mechanism, that is, the CRISPR-Cas system and their mode of action in conferring resistance to biotic stress, such as foreign genetic elements.

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

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

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

Crenactin is an actin ortholog identified in several crenarchaeal genomes, as well as in *Candidatus*Korarchaeumcryptofilum, and was shown to polymerize into cytoskeletal structure in the hyperthermophiliccrenarchaeaon *Pyrobaculumcalidifontis*. Immuno fluorescence 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 super family 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. Bhattacharyya C, Bakshi U, Mallick I, Mukherji, S, Bera B, and Ghosh A (2017) Genome-guided insights into the plant growth promotion capabilities of the physiologically versatile *Bacillus aryabhattai* strain AB211. *Frontiers in Microbiology* (doi: 10.3389/fmicb.2017.00411).
2. Chaudhury P, Neiner T, D'Imprima E, Banerjee A, Reindl S, Ghosh A *et al.* (2016) The nucleotide-dependent interaction of FlaH and FlaI is essential for assembly and function of the archaellum motor. *Molecular Microbiology* 99: 674-685.
3. Gupta S, Roy M, Ghosh A (2016) The archaeal signal recognition particle: present understanding and future perspective. *Current Microbiology* 74(2):284-297.

4. Mahanty T, Bhattacharyya S, Goswami M, Bhattacharjee P, Das B, Ghosh A, and Tribedi P (2016) Biofertilizers: a potential approach for sustainable agriculture development. *Environmental Science and Pollution Research* 24(4):3315-3335.

Grants-in-Aid Schemes:

Title of Project	Project funded by
Understanding protein translocation under extreme conditions	DST-Ramanujan Fellowship research grant, SERB, DST, Govt. of India
Investigation of the archaeal diversity and activity in Sundarbans mangrove sediment, India	CSIR, Govt. of India
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

Dr. Wriddhiman Ghosh

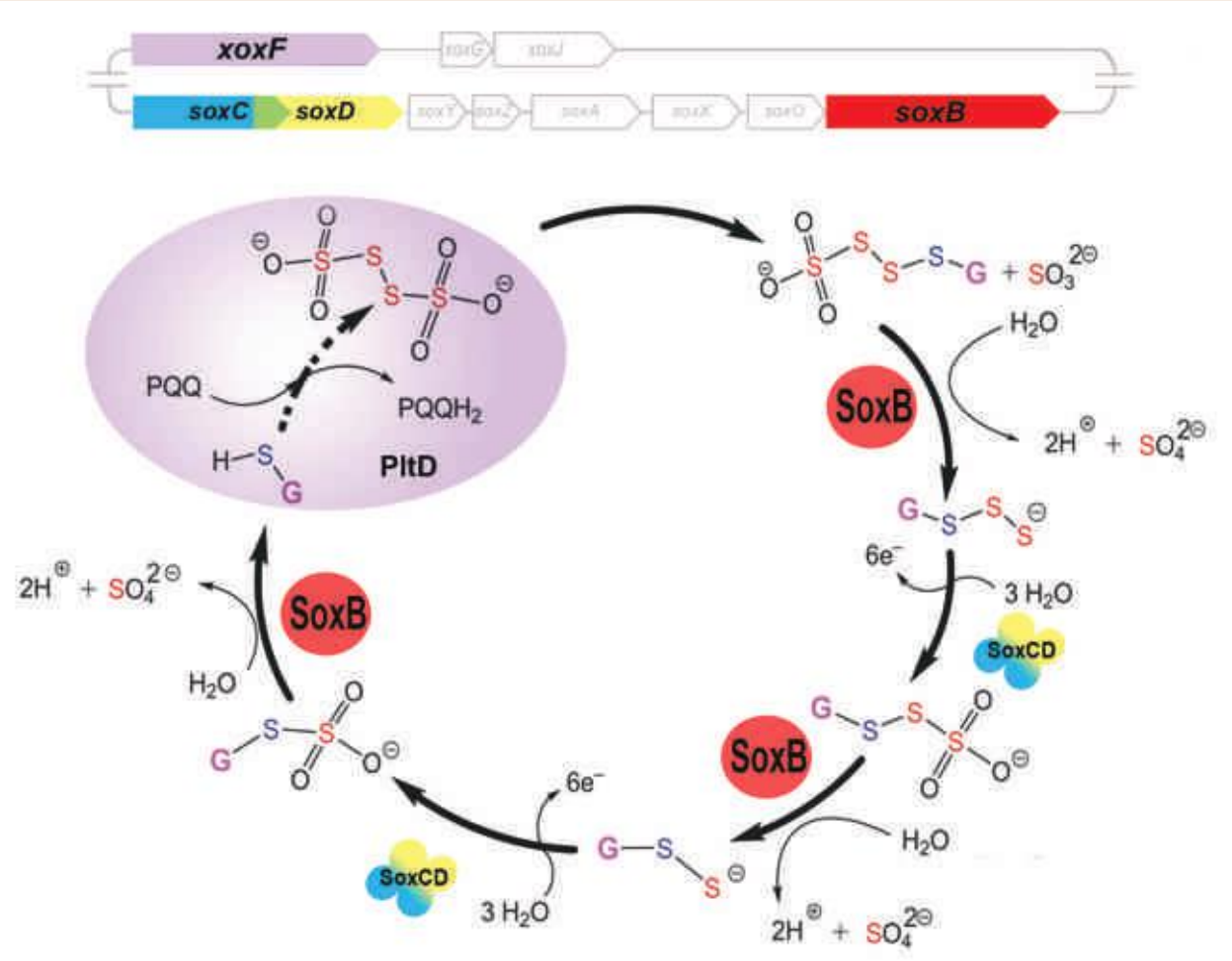
Assistant Professor

Scientific Reports

Homologs from sulfur oxidation and methanol dehydrogenation enzyme systems stitch-up a novel pathway of chemolithotrophic tetrathionate oxidation *in Advenella kashmirensis*

The SoxXAYZB(CD)$_2$-mediated pathway is the best-understood mechanism of bacterial sulfur-chemolithotrophy. It clearly explains the oxidation of thiosulfate, sulfide, elemental sulfur and sulfite, but not tetrathionate. The betaproteobacterium *Advenella kashmirensis oxidizes tetrathionate, besides forming it as intermediate (S_4I) during thiosulfate-oxidation. Its* genome possesses a *soxCDYZAXOB* gene-cluster, which was found here to be monocistronic and thiosulfate-/tetrathionate-inducible. Knock-out mutations showed that SoxBCD, but not SoxXAYZ, were involved in *A. kashmirensis* tetrathionate-oxidation, while S_4I-formation was Sox-independent. Results of Tn*5*-insertion mutagenesis, and comparative proteomics of chemolithotophically- versus chemoorganotrophically-grown cells, implicated glutathione as central to tetrathionate-oxidation. This was corroborated by the substrate-dependent oxygen-consumption patterns of whole-cells, and sulfur-oxidizing enzyme activities of cell-free extracts, obtained in the presence/absence of thiol-inhibitors/glutathione. Furthermore, in proteomics, a PQQ-containing methanol dehydrogenase (XoxF) homolog overexpressed five- and two-folds, respectively, during tetrathionate-oxidation and

S_4I-formation. Knock-out of the corresponding gene impaired tetrathionate-oxidation fully and S_4I-formation partially: hence it was named polythionate dehydrogenase (PltD). Homology-modeling and substrate-/ligand-docking indicated that PltD was competent to host intermolecular-reactions involving PQQ and thiosulfates; or PQQ, tetrathionate and glutathione. Consequently, thiosulfate dehydrogenation and tetrathionate:glutathione-coupling activities were checked, and proven, in the partially-purified PltD protein. Putative mechanisms of these reactions, plus the ground plan of tetrathionate-oxidation in *A. kashmirensis*, were modeled.



Publications :

1. Bose S, Mukherjee T, Sen U, Roy C, Rameez M J, Ghosh W (2016) Genome sequence of the multiple-protease-producing strain *Geobacillus thermoleovorans* N7, a thermophilic bacterium isolated from Paniphala Hot Spring, West Bengal, India. *Genome Announcements* 4(5): e01202-16.

2. Mukherjee T, Bose S, Sen U, Roy C, Rameez M J, Ghosh W and Mukhopadhyay SK (2016) Genome Sequence of the Red Pigment-Forming *Meiothermus taiwanensis* strain RP isolated from Paniphala Hot Spring, India. *Genome Announcements* 4(3): e00629-16.

3. Sen U , Mukherjee T , Bose S , Roy C , Rameez M J , Ghosh W (2016) Genome sequence of the arsenic-resistant *Haladaptatus* sp. strain R4 isolated from Ramnagar, West Bengal, India. *Genome Announcements* 4(5): e01017-16.

Grants-in-Aid Schemes :

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

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

Delivered a lecture titled "*The biophysical basis of habitability of hydrothermal vent ecosystems*" in a UGC-sponsored National Seminar on Modern Trends in Environmental Microbiology at the *Scottish Church College, Kolkata on January 30 – 31, 2017.*

Dr. Manikuntala Kundu

Senior Professor

Scientific Reports

The transcription factor MtrA of *Mycobacterium tuberculosis* regulates resuscitation promoting factors RpfA and RpfC: *in collaboration with Dr. Joyoti Basu and Dr. Sudipto Saha*

We have undertaken a detailed analysis of the regulation of transcription of the resuscitation promoting factor (Rpfs) RpfA and RpfC by *Mycobacterium tuberculosis* (Mtb) by the essential response regulator MtrA. We have performed electrophoretic mobility shift assays (EMSAs) to narrow down specific regions of binding of MtrA to the promoters of the above Rpfs. We have confirmed the specific binding sites by mutational analyses of the promoters and further undertaken analysis of promoter-GFP fusion constructs to validate the observations made by EMSA. Most interestingly, we have observed that during infection of macrophages with Mtb, MtrA likely regulates the expression of *rpfA* and *rpfC*.

Publication :

1. Banerjee S K, Kumar M, Alokam R, Sharma A K, Chatterjee A, Kumar, R, Sahu, S K, Jana, K, Singh R, Yogeeswari P, Sriram D, Basu J, Kundu M (2016) Targeting multiple response regulators of *Mycobacterium tuberculosis* augments the host immune response to infection. *Scientific Reports*. 6: 25851.

Dr. Pradeep Parrack

Professor

Scientific Reports

Publication :

1. Ghosh A, Dutta D, Bandyopadhyay K and Parrack P (2016) Characterization of the autophosphorylation property HflX, a ribosome-binding GTPase from Escherichia coli, *FEBS Open Bio* 6, 651-659.

Dr. Srimonti Sarkar

Associate Professor

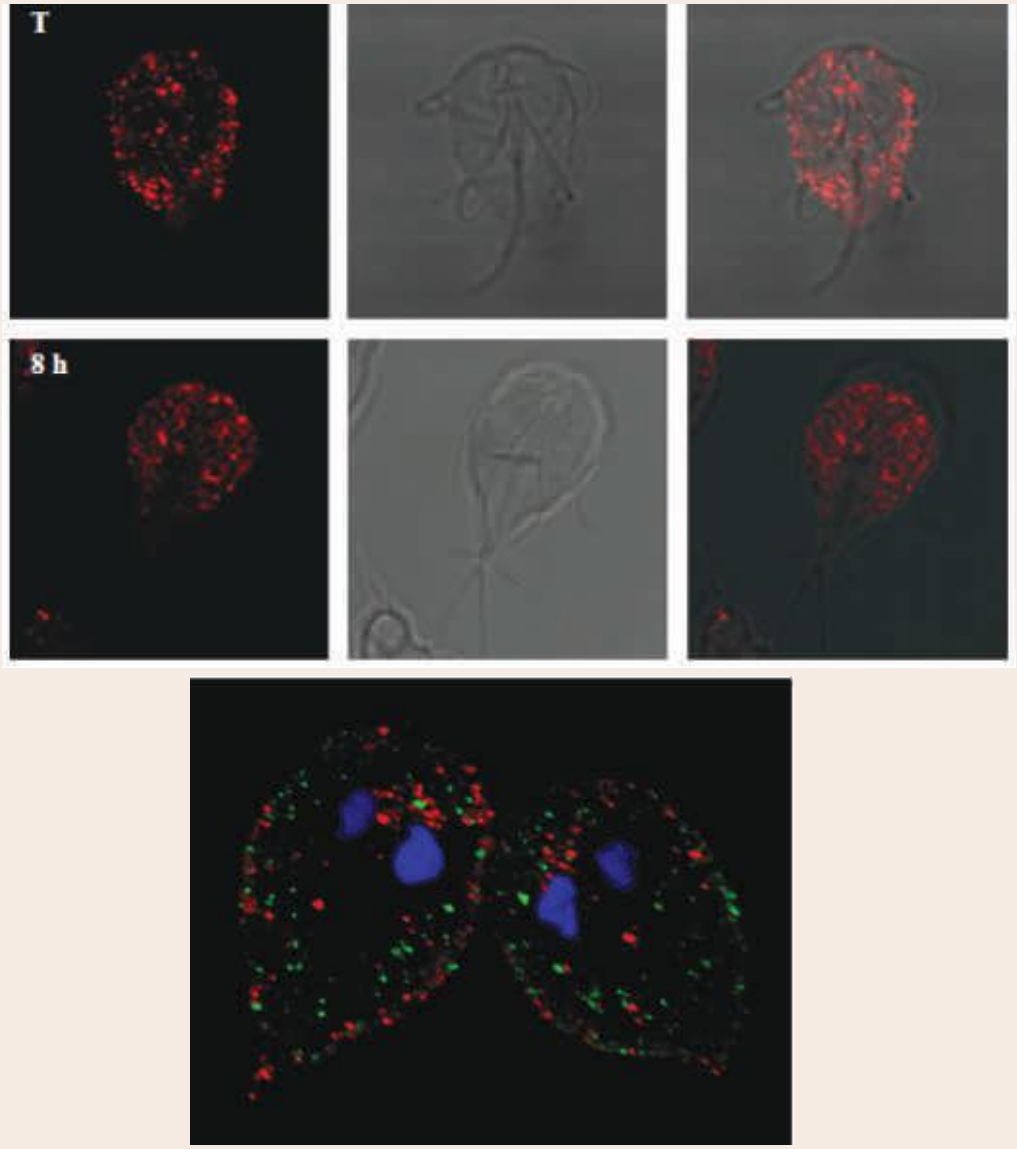
Scientific Reports

PX domains of *Giardia lamblia :*

Encystation is a very important event in the survival of the intestinal parasite *Giardia lamblia*. This is because while the trophozoite form of this protist colonizes the gut of its human host, its susceptibility to osmolysis does not allow it to survive outside the host. Thus, to move from one host to another, the trophozoites must undergo encystation as the resultant cysts, upon excretion by the host, can persist in the open environment till they can enter a new host.

During encystation cyst wall materials, packed in membrane vesicles, are targeted to the cell exterior. Regulatory lipids, residing in the cytoplasmic leaflet of these vesicles' membrane, play a major role in maintaining the fidelity of the targeting process. These regulatory lipids are recognized by cytoplasmic effector proteins with the help of their lipid-binding domains, such as the PX domains. My laboratory has identified six PX domain-containing proteins in *G. lamblia*. Some of the encoded PX domains contain non-canonical amino acid residues in the highly conserved ligand binding pocket. *In vitro* and *in vivo* binding studies indicate that these domains have the ability to bind to diverse phosphoinositides. Surprisingly, some of the PX domains that bind to the same lipid *in vitro*, exhibit significant differences in subcellular localization. Thus, besides the regulatory lipid itself, membrane targeting of a particular PX domain is likely to involve detection of additional physico-chemical parameters of membranes. Many of these PX domain-containing proteins have been documented to localize to the peripheral vesicles (PVs) of *Giardia*, which perform endo-lysosomal functions in the parasite. In addition to the PVs, one of the PX proteins also localizes to the base of the flagella (see figure below). Although two distinct puncta were observed at the flagellar base in trophozoites (top panels), these were absent in encysting

trophozoites after 8 hours of induction of encystation (bottom panels). Consistently, real-time analysis indicated that the corresponding gene was downregulated in encysting trophozoites. Thus, besides playing a role at the PVs, this PX protein may also participate in the regulation of flagellar function.



Cell: *Giardia lamblia :*

Protein: Two orthologues of SNAP, which are part of the vesicular trafficking machinery, localize to independent membrane-enclosed compartments of the binucleate human pathogenic protist, *Giardia lamblia.*

Secondary antibody tag: Alexa Flour 488, Alexa Flour 594, DAPI (Nucleus).

Here Z-stacks have been combined together in a maximum intensity projection image.

Publication :

1. Ray A and Sarkar S (2017) The proteasome of the differently-diverged eukaryote *Giardia lamblia* and its role in remodeling of the microtubule-based cytoskeleton. *Critical Reviews in Microbiology*. Volume 43 (4): 481-92 (DOI: 10.1080/1040841X.2016.1262814. [Impact Factor: 8.192]

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

(i) Attended and delivered invited talk at the 2nd International Conference on Translational Research, Bhubaneswar, India; (ii) Invited talk at the Summer School in Basic Sciences organized by Indian Association for Cultivation of Science, Kolkata in May, 2016.

Seminars / Symposia organized at Bose Institute :

(1) Symposium of the *Indian Society of Translational Research*; (2) Symposium entitled *The World of Microbes: Pathogenesis, Environment and Evolution.*

Dr. Subrata Sau

Professor

Scientific Reports

Studies on the protein folding enzymes involved in pathogenesis

FKBP22 acts as a peptidyl-prolyl *cis-trans* isomerase in *Escherichia coli*, a Gram-negative bacterium. Interestingly, some homologs of FKBP22 are involved in the pathogenesis as well. The N-terminal domains of FKBP22 and the related proteins are used for dimerization, whereas their C-terminal domains are employed for binding both the inhibitor and substrate. To understand the roles of a conserved Tyr residue at their N-terminal domains, we have created an FKBP22 mutant (Y15A) by replacing its Tyr residue at position 15 with an Ala residue. Studies on Y15A have revealed that the Tyr 15 of FKBP22 is crucial for preserving its catalytic activity, dimerization ability, and structure. However, the mutation did not affect the inhibitor binding ability or stability of FKBP22.

Staphylococcus aureus, a Gram-positive bacterium, synthesizes a cyclophilin (Cyp)-like peptidyl-prolyl *cis-trans* isomerase that is specifically inhibited by cyclosporin A (CsA). Studies have shown that it is involved both in the staphylococcal pathogenesis and protein folding. To understand the effects of CsA binding on Cyp, we have studied a recombinant Cyp (rCyp) in the presence and absence of this inhibitor. The data indicate that binding of CsA to rCyp partially changes its secondary structure, tertiary structure, and shape. The guanidine hydrochloride-induced equilibrium unfolding of both rCyp and rCyp-CsA occurred by a three-state mechanism via the

formation of one intermediate. Additionally, binding of CsA has also substantially enhanced the stability of rCyp, indicating that this protein may be useful for screening new antistaphylococcal agents in the future.

Publications :

1. Polley S, Chakravarty D, Chakrabarti G, Sau S (2016) Determining the roles of a conserved tyrosine residue in a Mip-like peptidyl-prolyl *cis-trans* isomerase. *Int J Biol Macromol.* 87:273-80. IF: 3.138

2. Polley S, Seal S, Mahapa A, Jana B, Biswas A, Mandal S, Sinha D, Sau K and Sau S (2017) Identification and characterization of a cyclosporin binding cyclophillin from *Staphylococcus aureus Newman. Bioinformation 13: 78-85. IF: 0.8*

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

Group Members :

Mr. Anindya Biswas presented a poster in the conference entitled “The World of Microbes: Pathogenesis, Environment and Evolution” held at Bose Institute, Kolkata on 17 October, 2016.

SCIENTIFIC REPORTS VI

Systems Biology

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

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

Information transmission in bacterial two-component system

Studies on the role of fluctuations in signal propagation and on gene regulation in monoclonal bacterial population have been extensively pursued based on the machinery of two-component system. The bacterial two-component system shows noise utilization through its inherent plasticity. The fluctuations propagation takes place using the phosphotransfer module and the feedback mechanism during gene regulation. To delicately observe the noisy kinetics the generic cascade needs stochastic investigation at the mRNA and protein levels. To this end, we propose a theoretical framework to investigate the noisy signal transduction in a generic bifunctional two-component system. The model shows reliability in information transmission through quantification of several statistical measures.

Interplay of synergy and redundancy in diamond motif

The formalism of partial information decomposition provides independent or non-overlapping components constituting total information content provided by a set of source variables about the target variable. These components are recognized as unique information, synergistic information and, redundant information. The metric of net synergy, conceived as the difference between

synergistic and redundant information, is capable of detecting synergy, redundancy and, information independence among stochastic variables. In the current project, we make use of this formalism to obtain a comprehensive understanding of the relative information processing mechanism in a diamond motif and two of its sub-motifs namely bifurcation and integration motif embedded within the diamond motif. The emerging patterns of synergy and redundancy and their effective contribution towards ensuring high fidelity information transmission are duly compared in the sub-motifs and independent motifs (bifurcation and integration).

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

Invited talk in Theoretical Chemistry Symposium at University of Hyderabad, December 14 – 17, 2016.

Dr. Joyoti Basu

Senior Professor and Coordinator

Scientific Reports

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

Epigenetic modifications have emerged as important regulatory mechanisms which guide the immune response to infection. Among these are the covalent post-translational modification of core histones. In continuation of our earlier work on H3K4-methylation that occurs across the macrophage genome in response to infection by *Mycobacterium tuberculosis* (Mtb), we have now gleaned insight into the significance of global H3K4Me3 trimethylation by focusing on a set of genes of relevance to infection. We observe that H3K4Me3 methylation regulates the expression of the chromatin loopscape regulator SATB1. SATB1 levels are differentially regulated during infection by virulent Mtb H37Rv vs. avirulent Mtb H37Ra. SATB1 in turn represses the expression of a specific set of cytokines which are of relevance to infection. Epigenetic mechanisms are therefore of significance in differentially regulating the global chromatin architecture during infection by virulent vs. avirulent Mtb, thereby subtly modifying the innate immune response in a temporal manner.

Publication :

1. Banerjee S K, Kumar M, Alokam R, Sharma AK, Chatterjee A, Kumar R, Sahu SK, Jana K, Singh R, Yogeeswari P, Sriram D, Basu J, Kundu M (2016) Targeting multiple response regulators of *Mycobacterium tuberculosis* augments the host immune response to infection, *Scientific Reports*. 6: 25851.

Students awarded Ph.D.:

Name of the Students (University/ Year)	Titles of Thesis
Joint Supervisor: Dr. Manikuntala Kundu	
Shamba Gupta (CU, 2016)	Understanding proteins of the cell division machinery in mycobacteria

Grants-In-Aid Schemes :

Title of the scheme	Schemes funded by
with Dr.Manikuntala Kundu and Dr. Jayanta 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
The role of secreted antigen Rv0009 of *Mycobacterium tuberculosis* in modulating signaling in macrophages	DAE
Sys TB: A Network Program for Resolving the Intracellular Dynamics of Host Pathogen Interaction in TB Infection	DBT

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

Delivered talks in (i) Symposium organized in connection with the 80th anniversary celebrations of Indian Institute of Chemical Biology, Kolkata in June, 2016; (ii) XL All India Cell Biology Conference & International Symposium on Functional Genomics and Epigenomics organized by Jiwaji University, Gwalior in November, 2016; (iii) 26thECCMID Congress, the European Congress of Clinical Microbiology and Infectious Diseases, Amsterdam, Netherlands, April, 2016.

Group Members :

Manish Kumar, CSIR Senior Research Fellow presented a poster in the EMBO conference "Innate Immunity in Host-Pathogen Interactions", held at the European Molecular Biology Laboratory (EMBL), Heidelberg, Germany from June 26 – 29, 2016.

Dr. Indrani Bose

CSIR-Emeritus Scientist

Scientific Reports

In population biology, the Allee dynamics refer to negative growth rates below a critical population density. In continuation of the research studies initiated earlier, we have studied a reaction-diffusion

(RD) model of population growth and dispersion in one dimension, which incorporates the Allee effect in both the growth and mortality rates. For the full RD model, the existence of travelling wave solutions of the population density has been demonstrated in agreement with the experimental observation of such waves in populations of budding yeast. In a travelling wave, populations occupy new territory (range expansion) through a combination of local growth and diffusion. In the case of a pulled wave, the range expansion is dominated by the dynamics at low population density prevailing at the very edge of the wavefront which pull the wave forward. In the case of a pushed wave, the speed of the travelling front is determined by the whole front rather than by only the leading edge. The theoretical prediction of a pulled to pushed wave transition has recently been verified in an experiment on budding yeast as the cooperativity in growth was increased. The Model studied by us demonstrates the pulled to pushed wave transion in range expansion. The strength of the model lies in the fact that the growth and mortality rate constants appear explicitly as parameters in the model which are experimentally controllable.

Some recent experiments provide evidence of the ability of plants to learn and exhibit the characteristic features of associative memory. We have initiated a study of the biophysical principles underlying learning and memory with the aim to develop neural network like models which can explain some of the experimental observations. We have initiated a study on the balance between cell division and differentiation using the theory of branching processes. The problem studied can further be mapped onto Kelly's gambling problem which is known to be relevant to bacterial decision making when the bacterial population is subjected to stresses like nutrient depletion.

Publication :

1. Bose I, Pal M and Karmakar C (2017) Allee dynamics: Growth, extinction and range expansion, *International Journal of Modern Physics* C 28, 1750074, 12 pages.

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

I) Delivered on invitation a talk titled “Nonlinearity and noise determine cellular fate” at UGC sponsored National Seminar on Chemistry Education and Research in Daily Life (January 6 – 7, 2017) at Ramakrishna Vivekananda College, Belur Math; (ii) talk on “Growth, Extinction and Invasion” at Mini Conference on Statistical Physics, Physics Department, Calcutta University (March 17, 2017); Delivered on invitation (iii) the 2nd Acharya J C Bose Memorial Oration titled “Noise in the Living Cell” at IIEST, Shibpur, Howrah (August 10, 2016) (iv) a lecture titled “Cell Differentiation: A Physicist's Perspective” as part of Interdisciplinary Seminar sponsored by DBT Star College Grant at St. Xavier's College, Calcutta (September 19, 2016) (v) two lectures on “Phase Transitions, Critical Phenomena and the Ising Model” at the Physics Department, Amity University, Kolkata (November 17 – 18, 2016) (vi) a Colloquium titled “Noise in the Living Cell” at Physics Department, Nagpur University (March 17, 2017).

Dr. Zhumur Ghosh

Assistant Professor

Scientific Reports

Characterizing the naïve and primed pluripotent states

Elucidated the key transcription factors pertaining to these pluripotency states (by analyzing corresponding microarray datasets) which have been subsequently validated in these two pluripotency states.

Elucidating the complex crosstalk between cancer stem cells and non-stem cancer cells in high grade serous ovarian cancer

We have taken up a systems approach to find out whether non-CSC cancer cells share a common core of gene interaction with cancer stem cells (CSCs) in high-grade serous ovarian carcinoma. We found that there is a significant gene expression overlap as well as commonality in the gene interaction paths between cancer cells and CSCs which support their co-existence. We have elucidated a set of transcription factors (named as pivot-TFs) which brings in subtle alterations in the mode of gene regulation along these paths and eventually defines two distinct interactomes corresponding to these two cell states.

© Identifying a circuit involving miRNA-26a and TFs- KLF4, CREB and C/EBP-β that leads to enhanced survival of Mycobacterium tuberculosis: *in collaboration with Dr. Joyoti Basu and Dr. Manikuntala Kundu*

In this work we have identified a circuit involving miRNA-TF interaction which regulates the polarization of macrophages and the trafficking of Mycobacterium tuberculosis to lysosomes during infection. miR-26a and the transcription factors, KLF4, CREB and C/EBP-β form a close circuit that is associated with mycobacteria-induced M2 polarization, repression of autophagy and lysosomal trafficking of Mtb leading to enhanced survival of the bacterium.

Publication :

In conference proceedings :

1. Deb A, Sarkar A, Ghosh Z (2017) Key Transcription Factors dictating cellular fates in pluripotent stem cells, "*3rd International Conference on Perspective of Cell Signaling and Molecular Medicine*", Kolkata, India.

Grant-in-Aid Schemes :

Title of the scheme	Schemes funded by
Epigenetic alterations inducing oncogenic transformation in stem cell derivatives	ICMR

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

Group Members :

Aritra Deb presented his work entitled "Key Transcription Factors dictating cellular fates in pluripotent stem cells" 3rd International Conference on Perspective of Cell Signaling and Molecular Medicine, Bose Institute Kolkata (8th to 10th Jan, 2017).

Dr. Manikuntala Kundu

Senior Professor

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

We have continued our exploration of the global mRNA-miRNA expression network during infection of gastric epithelial cells with Helicobacter pylori (Hp). We have characterized in detail the miRNA-dependent regulation of the AKT kinase signalling pathway regulated by the AKT2 kinase inhibitor PHLPP1. MiRNA mediated downregulation of PHLPP1 augments the activity of the kinase AKT2. This in turn turns on NF-kappa B-dependent signalling which regulates expression of the matrix metalloproteinases MMP2 and MMP9. These are intimately related to the invasiveness of gastric epithelial cells. We show that wound healing is regulated by miRNA-PHLPP1-AKT2 dependent signalling. We propose that these have important roles during Hp infection of gastric tissues.

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

One of the two component systems, SenX3-RegX3 of *Mycobacterium tuberculosis* (Mtb)is known to be responsible for the survival of bacteria under phosphate stress. In continuation of our earlier work on the global regulation of gene expression by RegX3, we have now validated that RegX3 binds to the promoters of *whiB3* and *whiB7* to regulate their expression. Mutational analyses in EMSAs have confirmed the RegX3 binding sites. These have been further corroborated by analyses of promoter GFP fusion constructs. The relevance of RegX3-mediated regulation of the above whiB genes is under investigation.

Publication :

1. Banerjee S K, Kumar M, Alokam R, Sharma A K, Chatterjee A, Kumar R, Sahu S K, Jana K, Singh R, Yogeeswari P, Sriram D, Basu J, Kundu, M (2016) Targeting multiple response regulators of Mycobacterium tuberculosis augments the host immune response to infection, *Scientific Reports* 6: 25851.

Grants-In-Aid Schemes :

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

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

Presented her work in the "Cell Symposium: 100 Years of Phagocytes" being organized by Elsevier at Hilton Giardini Naxos, Sicily, Italy from 19 – 22 September, 2016.

Dr. Jayanta Mukhopadhyay

Associate Professor

Scientific Reports

In vitro study of input-output robustness of MprAB signaling pathway in Mycobacterium tuberculosis: *in collaboration with Dr. Suman Banik*

M. tuberculosis while responding to a particular external stimulus utilizes its machinery of two component systems (TCSs) each comprising a paired sensor kinase and its cognate response regulator. One of such TCS in *M. tuberculosis* is MprAB having the sensor kinase MprB and the response regulator MprA, encoded by the operon *mprAB*. In presence of external stimulus MprB shows bi-functional behavior by acting as kinase as well as phosphatase towards its cognate response regulator MprA. The pool of phosphorylated MprA acts as a transcription factor for expression of genes. Considering the influx of the external stimulus and the consequent outflux via the formation of phosphorylated response regulator, one can define an input-output relation using the framework of bacterial TCS. It has been predicted that the phosphorelay based signalling machinery is likely to be insensitive to the variation in systems components that eventually leads to a robust signalling framework. To validate the input-output relation in MprAB TCS of *M. tuberculosis,* we used *in vitro* transcription assay and *in vivo* reporter assay to monitor various parameter of the signaling network and infer the relationship between the network components by mathematical modeling.

Publications :

1. Datta A, Yadav V, Ghosh A, Choi J, Bhattacharyya D, Kar R K, Ilyas H, Dutta A, An E, Mukhopadhyay J, Lee D, Sanyal K, Ramamoorthy A and Bhunia A (2016) Mode of Action of a Designed Antimicrobial Peptide:High Potency Against Cryptococcus neoformans. *Biophysical Journal* 111: 1724–1737.
2. Prajapati RK, Sengupta S, Rudra P, and Mukhopadhyay J (2016) Bacillus subtilis σ^{I} factor functions as a transcriptional regulator by facilitating the open complex formation. *J Biol Chem* 291(3):1064-75.
3. Roy A, Dutta A, Roy D, Ganguly P, Ghosh R, Kar R K, Bhunia A, Mukhopadhyay J and Chaudhuri S (2106) Deciphering the role of the AT-rich interaction domain and the HMG-box domain of ARID-HMG proteins of Arabidopsis thaliana. *Plant Molecular Biology* 92(3):389-390.

Students awarded Ph.D.:

Name of Students (University/ Year)	Titles of Thesis
Paulami Rudra (C.U., 2016)	Mechanism of inhibition of transcription by Rv1222 of Mycobacterium tuberculosis.
Ranjit Kumar Prajapati (C.U., 2016)	Study of interaction of delta subunit with RNA polymerase of bacillus subtilis.
Shreya Sengupta (C.U., 2016)	Study of 'sigma cycle' paradigm in Bacillus subtilis.

Grants-in-Aid Schemes :

Title of the scheme	Schemes funded by
(Jointly with Dr S Banik (Project coordinator), and Dr M. Kundu)	
In vitro study of input-output robustness of MprAB signalling pathway in *Mycobacterium tuberculosis*	DBT
(Jointly with Dr R. Sen)	
Characterization and design of inhibitors of Mycobacterium tuberculosis transcription.	DBT

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

i)19th Transcription Assembly Meeting, Bose Institute, November 8 – 9, 2016. Bacillus subtilis δ factor is not a subunit of RNA polymerase, rather functions as a transcription regulator ii) 19th Transcription Assembly Meeting, Bose Institute, November 8 – 9, 2016. Novel mechanism of gene regulation: the protein Rv1222 of Mycobacterium tuberculosis inhibits transcription by anchoring the RNA polymerase onto DNA. (student talk by Paulami Rudra) iii)ASM Conference on Antibacterial Development, December 11 – 14, 2016 Washington DC. Effect of rifabutin analog RFA-1 on rifampicin resistant RNA-polymerase. iv) Meeting on Molecular Microbiology (MCube), February 10 – 11, 2016. *Bacillus subtilis* δ factor: a subunit of RNA polymerase or a transcriptional regulator?

Dr. Sudipto Saha

Assistant Professor & Ramalingaswami Fellow

Systemic discovery of biomarkers of asthma using human plasma proteomics, cytokine profiling and network biology – a systems approach to drug discovery: *in collaboration with Dr. Swati Gupta Bhattacharya*

Asthma is a complex heterogeneous air-way inflammatory disorder, which is still under-diagnosed and untreated. We have performed quantitative label free proteomics analysis and cytokine profiling on severe asthma patient blood samples (n = 12) for identification of potential biomarkers. We identified that the family of apolipoproteins (A1, B and E) and IL-33 were differentially expressed. The pathway and network analyses were performed on the merged proteomic and cytokine assay dataset, which reveal that there is a cross-talk between ApoE and IL-33 cytokine. This study allows us to identify drug targets of asthma and explore the mechanism of IL-33 mediated regulation of apolipoproteins.

Identifying systems level cellular networks and pathways that are involved in *Mycobacterium tuberculosis* drug resistance (MDR-TB): *in collaboration with Dr. Joyoti Basu*

We are studying *Mycobacterium tuberculosis* (MTB) gene mutations that are responsible for drug resistance. We are interested to know whether MTB drug resistance genes mutations rewire intra species and host-MTB protein-protein interaction networks. This study will allow us to identify drug resistance escape mechanism pathways/networks and develop better drugs against MDR-TB.

Grants-in-Aid Schemes :

Title of the scheme	Schemes funded by
With Dr. Swati Gupta-Bhattacharya (Joint PI) Systematicdiscovery of biomarkers of asthma caused by common environmental allergens using plasma proteomics, cytokine profiling and network biology- a systems approach to drug discovery	ICMR

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

(I) Oral presentation on “Plasma Apolipoproteins – Potential Biomarkers inAtopic Asthma based on LC-MS/MS study”at Keystone symposia on Asthma: From Pathway Biology to Precision Therapeutics, February 12 – 17, 2017, at Keystone Resort, Keystone, Colorado, USA; (ii) Oral presentation on “Towards Cataloging Genes Associated with Drug Resistance and their Protein-Protein Interaction Networks” at UK-India Workshop on Tackling the Emergence of Antimicrobial Resistance, 7-10 November 2016,Chandigarh, India.

SCIENTIFIC REPORTS

VII

Basic and Applied Problems in Physical and Environmental Sciences

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

Dr. D. Home (Coordinator), Dr. S. Raha, Dr. B. K. Chatterjee, Dr. Indrani Bose, Dr. Sanjay Kr. Ghosh, Dr. S. K. Saha, Dr. T. P. Sinha, Dr. Pradeep Das, 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. Sanat Kumar Das, Dr. Sidharth Kumar Prasad and Dr. Saikat Biswas.

Introduction

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

Dr. Somshubhro Bandyopadhyay

Associate Professor

Scientific Reports

Theoretical Research

A. Characterization of entanglement as a resource for local state discrimination problems: *in collaboration with Saronath Halder and Michael Nathanson, St. Mary's College, California*

We have continued our efforts to better understand the role of quantum entanglement as a resource in quantum information processing tasks. In particular, we have done a complete characterization of resource states in the problem of quantum state discrimination in multipartite systems. This characterization allowed us to introduce the paradigm of LOCCE, short of Local Operations, Classical Communication and Entanglement and also define the notions of “useful” and “optimal”

resource states based on reasonable physical criteria. These notions are further illustrated with additional results and example from both bipartite and multipartite systems.

We have also considered the problems of optimal discrimination of GHZ and graph states in many-qubit systems. Here we have shown that a (m.m) GHZ state is an optimal resource for perfect discrimination of a (N,m) GHZ basis for any partitioning of N qubits among m parties.

B. Entanglement gain in quantum measurements with unknown results: *in collaboration with Tomasz Paterek group, NTU, Singapore*

We consider the question of entanglement gain in quantum measurements with unknown results. By this we mean the following. Suppose I have a quantum measurement device which churns out output states without post-selection. We ask whether it is possible to observe any gain in entanglement in the process. We have shown that for any input state there exists a measurement such that entanglement gain is possible. On the other hand, a measurement in a maximally entangled basis cannot increase entanglement of any input state. This problem is also being investigated in open quantum systems.

C. Polynomial representation of quantum entanglement : *in collaboration with Ajit Iqbal Singh*

We give polynomial representation of quantum entanglement for pure states in multipartite systems and illustrate with several examples. We further provide rational functional representation of density operators and study Schmidt decomposition for bipartite pure states.

1. Quantum Optics Laboratory

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

Publications :

1. Bandyopadhyay S, Halder S and Nathanson M (2016).*Entanglement as a resource for local state discrimination in multipartite systems, Phys. Rev. A 94, 022311.*
2. Bandyopadhyay S, Banik M , Bhattacharya S Sankar , Ghosh S, Kar G , Mukherjee A, Roy A (2016) *Reciprocal ontological models show indeterminism of the order of quantum theory, Foundations of Physics* 47(2), 265-273.

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

(i) Visited The Institute of Mathematical Sciences, Chennai, August 2016. (ii) Delivered invited talk on “Entanglement as a resource for local state discrimination”, at the 2nd International Conference on Quantum Foundations 2016, NIIT Patna, November 2016. (iii) Attended and advised as the Director's nominee in two DRDO meetings related to the future activities of JCBCAT (Jagadish Chandra Bose Center for Advanced Technology). (iv) Delivered Invited talk in DRDO/JCBCAT-JU one day workshop on Quantum Technologies.

Grant-in-Aid Schemes :

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

Dr. Saikat Biswas

Assistant Professor

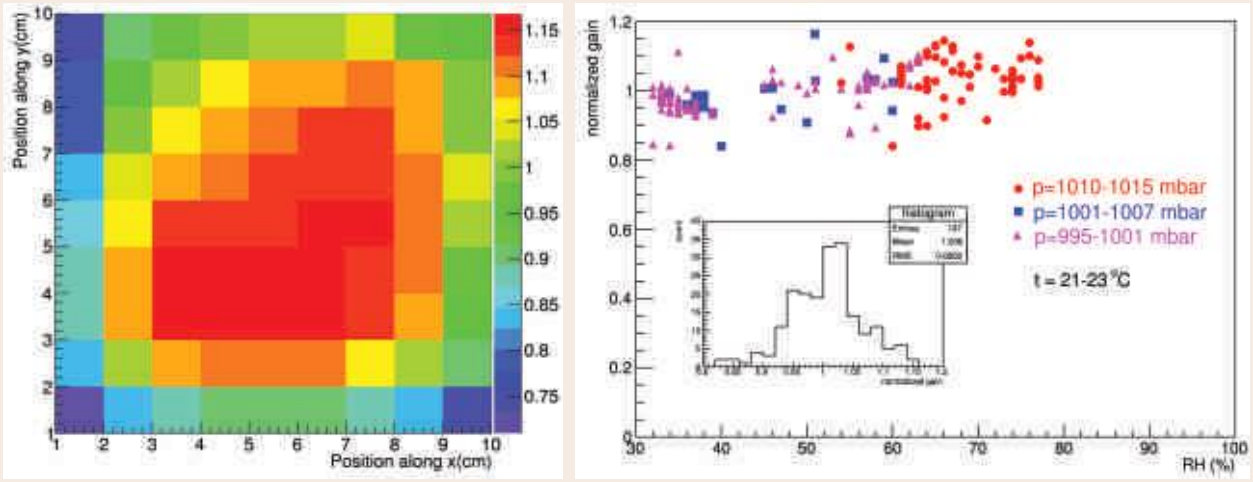
Scientific Reports

Long-term stability test of a triple GEM detector: *In collaboration with Mr. R. P. Adak, Dr. S. Das, Prof. S. K. Ghosh, Mr. D. Nag, Dr. S. K. Prasad, Prof. S. Raha, Mr. D. Ghosal (ISM, Dhanbad), Mr. A. Mondal (University of Calcutta), Dr. T.K. Nayak, Mr. R.N. Patra (VECC), Dr. P.K. Sahu, Mr. S. Sahu and Ms. S. Swain (IOP, Bhubaneswar)*

The main aim of the study is to perform the long-term stability test of gain of the single mask triple GEM detector. Triple GEM detector prototype is built and tested with a gas mixture of Ar/CO_2 of 70/30 volume ratio. The long-term stability test of this detector is performed using Fe^{55} X-ray source. The gain is measured and normalized for the T/p effect. In the analysis the rate of the X-ray from the source is modified according to the radioactive decay law. However, in the 750 hours of long-term study the rate decreased from 350 kHz to 342.4 kHz that is only 2.17% of the starting value. In this measurement only a fluctuation about the mean value of 1.003 in the normalized gain is observed after T/p correction. No ageing is observed till an accumulation of charge per unit area > 12.0 mC/mm^2. From these results it can be concluded that triple GEM detector can safely be used in high-energy physics experiments where a long-term stability of the detector is an essential criterion.

The study is further extended with a constant gas flow rate and uninterrupted application of high voltage. In the repeated measurement even better stability is observed.

Variation of gain over the active area of the detector has been checked, and the result shows a variation of ~11.7% over the area of 10×10 cm^2. Tests have been done to check the dependence of gain on relative humidity, and the results show that gain does not show any correlation with relative humidity.



(Left) The distribution of normalized gain on the active GEM area. (Right) The normalized gain as a function of relative humidity. (Inset) The distribution of normalized gain for all the data points.

Study of some aspects of straw tube detectors: *In collaboration with Ms. S. Roy, Mr. R. P. Adak, Dr. S. Das, Prof. S. K. Ghosh, Mr. D. Nag, Dr. S. K. Prasad, Prof. S. Raha, Dr. S. Chatttopadhyay, Mr. J. Saini (VECC), Mr. D. Ghosal (ISM, Dhanbad), Mr. A. Mondal (University of Calcutta), and Mr. D. Paul (Ananda Mohan College, Kolkata).*

Basic characteristic studies are performed for straw tube detector with $Ar + CO_2$ gas in 70:30 ratios using conventional NIM electronics. In this study count rate, ion charge per particle or the effective gain, signal attenuation and uniformity of performance are studied systematically. Dependence of rate on relative gain is observed and a severe effect is observed above a rate per unit area of 19 kHz/cm^2. Use of the straw tube detector in CBM MuCh is under investigation.

Design and fabrication of data logger to measure the ambient parameters in gas detector R&D: *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)*

A novel instrument (Data logger) has been developed to monitor and record the ambient parameters such as temperature, atmospheric pressure and relative humidity. With this data logger continuous recording of temperature, atmospheric pressure, relative humidity and the time stamp can be done with a programmable sampling interval. The device is interfaced with computer by Lab-view software. This instrument is very economical and these parameters are very essential for understanding the characteristics of gas filled detectors such as Gas Electron Multiplier (GEM) and

(Left Top) The straw tube prototype : 6 straws, each of diameter 6 mm and length 20 cm.
(Left Bottom) The Fe^{55} signal in the oscilloscope at 1650 V (20 mV/Div, 20 ns/Div, 50Ω load). (Right) Set-up with all the detectors, rack of scintillators and electronics rack.

Multi Wire Proportional Counter (MWPC). 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.

Development of cosmic ray air shower array with active detectors at Darjeeling: *In collaboration with Dr. S. Das, Prof. S. K. Ghosh, Mr. D. Nag, Prof. S. Raha and Ms. S. Roy.*

An array of plastic scintillator detectors is proposed 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. Each element of this array is a 1 m × 1 m plastic scintillator detector of thickness 1 cm, coupled with WLS fibers and a PMT. During the first phase seven of these modules arranged in a hexagonal way keeping one at the centre of the hexagon will be commissioned. Four such modules have already been built and tested. As a proof of principle three of these detectors are used to detect cosmic ray shower. The three-fold coincidence from a stack of 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.

(Left) Steps of scintillator detector fabrication. (Right) Horizontal stack of three scintillator detectors to measure cosmic ray shower.

Publications :

1. Adak R P, Biswas S, Das S, Ghosal D, Ghosh S K, Mondal A, Nag D, Nayak T K, Patra R, Prasad S K, Raha S, Sahu P K, Sahu S and Swain S (2016) Long-term stability test of a triple GEM detector; JINST 11 T10001 doi:10.1088/1748-0221/11/10/T10001. [arXiv:1608.00562], Impact Factor: 1.2
2. Abuhoza A, Schmidt H R, Biswas S, Frankenfeld U, Hehner J, Schmidt C J (2016) Building and commissioning of a setup to study ageing phenomena in gaseous detectors; *Nuclear Instruments and Methods in Physics Research A* 824, 487-489; Impact Factor: 1.2
3. Biswas S, Schmidt D J, Abuhoza A, Frankenfeld U, Garabatos C, Hehner J, Kleipa V, Morhardt T, Schmidt C J, Schmidt H R, and Wiechula J (2016) Systematic measurements of the gain and the energy resolution of single and double mask GEM detectors, *Nuclear Instruments and Methods in Physics Research A* 824, 504-506, [arXiv:1505.07767], Impact Factor: 1.2
4. Meghna K K, Biswas S, Jash A, Chattopadhyay S, Saha S (2016) Effects of variation of environmental parameters on the performance of Resistive Plate Chamber detectors; *Nuclear Instruments and Methods in Physics Research A* 816, 1-8, Impact Factor: 1.2
5. Nandan Akhilesh P, Rudra Sharmili, Neog Himangshu, Biswas S, Mahapatra S, Mohanty B, Samal P K (2016) A simple technique for gamma ray and cosmic ray spectroscopy using plastic scintillator; *Nuclear Instruments and Methods in Physics Research A* 824, 606-608. [arXiv:1407.7181], Impact Factor: 1.2
6. Patra Rajendra Nath, Nanda Amit, Rudra Sharmili, Bhattacharya P, Sahoo Sumanya Sekhar, Biswas S, Mohanty B, Nayak T K, Sahu P K, Sahu S (2016) Characterisations of GEM detector prototype; *Nuclear Instruments and Methods in Physics Research A* 824, 501-503, [arXiv:1505.07768], Impact Factor: 1.2

Conference proceedings :

1. Adak R P, Biswas S, Chattopadhyay S, Das S, Ghosal D, Ghosal P, Mondal A, Nag D, Roy S and Saini J (2016) R&D on Straw Tube detector for CBM Muon Chamber; *Proceedings of the DAE-BRNS Symposium on Nuclear Physics,* Volume 61, 996-997.
2. Adak R P, Biswas S, Das S, Ghosal D, Ghosh S K, Mondal A, Nag D, Nayak T K, Patra R N, Prasad S K, Raha S, Sahu P K, Sahu A and Swain S (2016) Stability test of the GEM detector, *Proceedings of the DAE-BRNS Symposium on Nuclear Physics*, Volume 61, 998-999.
3. Nag D, Biswas S, and Das S (2016) Design and fabrication of a MHz scaler module; *Proceedings of the DAE-BRNS Symposium on Nuclear Physics*. Volume 61, 982-983.
4. Nag D, Kumar A, Biswas S, Chattopadhyay S, Das S, Dubey A K, Ghosh C, Prasad S K and Saini J (2016) Design and fabrication of a water based cooling system for the CBM Muon Chamber; *Proceedings of the DAE-BRNS Symposium on Nuclear Physics;* Volume 61, 1096-1097.
5. Patra Rajendra Nath, Singaraju R N, Biswas S, Ahammed Z, Nayak T K, Viyogi Y P (2016) Characteristics of triple GEM detector for the ALICE TPC up-grade at CERN; *Proceedings of the DAE-BRNS Symposium on Nuclear Physics;* Volume 61, 1050-1051.
6. Patra Rajendra Nath, Singaraju R N, Ghosh T K, Biswas S, Nayak T K, Viyogi Y P (2016) Study of a Multiwire Proportional Chambers (MWPC) detector using NIM and MANAS based electronics; *Proceedings of the DAE-BRNS Symposium on Nuclear Physics;* Volume 61, 1052-1053.
7. Sahu S, Sahu P K, Swain S and Biswas S (2016) Building of Gas Flow Monitor for GEM Detector; *Proceedings of the DAE-BRNS Symposium on Nuclear Physics*; Volume 61, 1002-1003.
8. Swain S, Adak R P, Biswas S, Patra R N, Rudra S, Sahu P K, and Sahu S (2016) Building of a 4-GEM prototype for ALICE-TPC upgrade; *Proceedings of the DAE-BRNS Symposium on Nuclear Physics,* Volume 61, 994-995.

Grants-in-Aid Schemes :

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 :

(i) Attended 27th CBM Collaboration meeting, GSI, Darmstadt, Germany, April 11 – 15, 2016;

(ii) SXC Workshop on Astroparticle Physics: May 26 – 30, 2016, Bose Institute, Darjeeling.

Title of the talk: (a) Detectors in experimental high energy physics. (b) Advanced gaseous detectors for high energy physics experiments;

(iii) Special Task Force meeting, September 2 – 4, 2016, BARC, Mumbai;

Title of the talk: ALICE TPC Upgrade with GEM detectors for high rate operations;

(iv) National Conference on "Advanced Detectors for Nuclear, High Energy and Astroparticle Physics", February 15 – 17, 2017, Bose Institute, Kolkata, India;

(v) INSTR17: International Conference "Instrumentation for Colliding Beam Physics", Budker Institute of Nuclear Physics, and Novosibirsk State University, Novosibirsk, Russia February 27 – March 3, 2017,

Title of the talk: Study of some aspects of straw tube detectors for CBM-MuCh ;

Title of the poster: (a) Design and fabrication of a data logger for atmospheric pressure, temperature and relative humidity for gas-filled detector development; (b) Development of scintillator detector for detection of cosmic ray shower.

Seminars / Symposia organized at Bose Institute :

Convener of National Conference on "Advanced Detectors for Nuclear, High Energy and Astroparticle Physics", February 15 – 17, 2017, Bose Institute, Kolkata, India.

Social Relevance :

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.

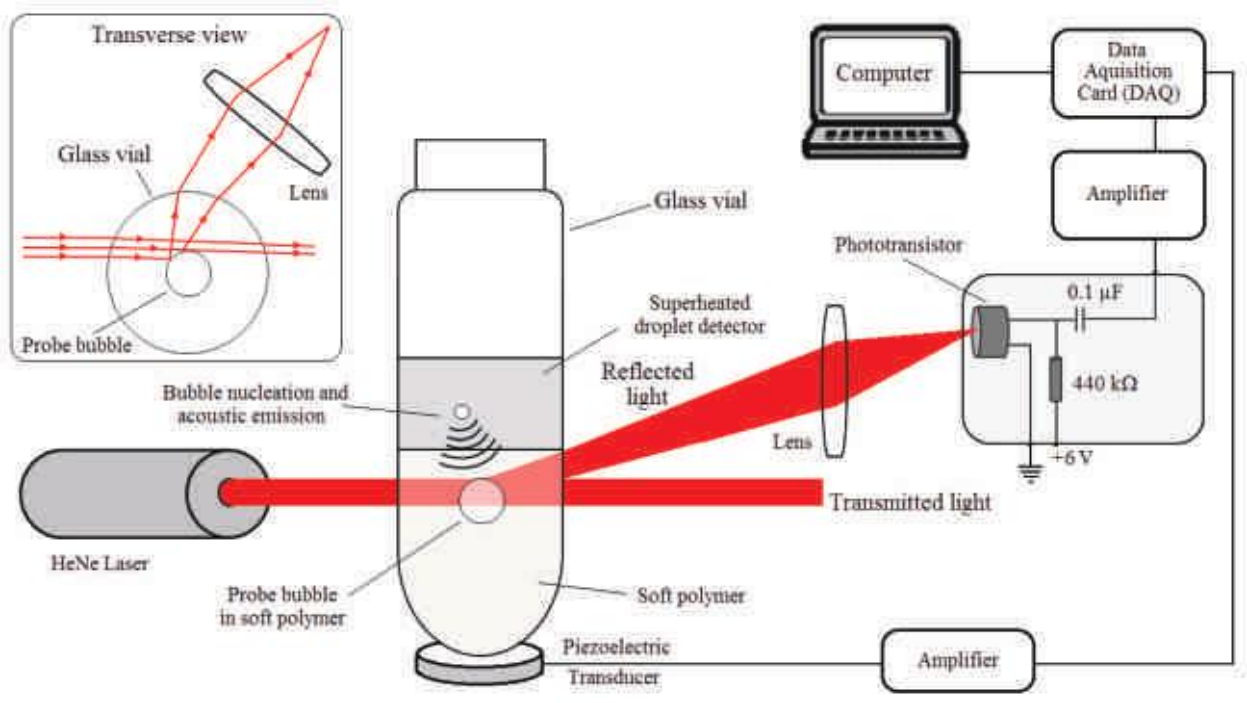
Dr. Barun K. Chatterjee

Senior Professor

Scientific Reports

Study of liquid-vapor nucleation in superheated drop detectors

The process of vaporization of a superheated liquid droplet, proceeds through the growth of a microbubble in the superheated liquid (nucleation) and this growth process is accelerated and at some radius the radial velocity exceeds the velocity of sound in the superheated liquid giving rise to a shock wave and the evaporation of most of the remaining liquid. An optical system has been used to detect the acoustic emission from the nucleated droplet.



A laser light reflected from a probe bubble is focused on a photo transistor and the variation of the intensity is seen to follow the bubble oscillation. Though the droplets of the superheated liquid are polydisperse (are of different diameters) the Fourier transform of the observed signal shows two dominant peaks, a large one at a fixed low frequency (corresponding to the fundamental mode of the larger probe bubble) and another at a higher frequency which is variable. This indirectly indicates the presence of a shock wave which sets the probe bubble into free oscillation, while the other one is due to the forced oscillation due to the sound wave from the newly created vapor bubble.

Publications :

1. Chatterjee T, Chatterjee B K, Saha Tultul, Hoque Kazi Mirajul, Chakrabarti P (2017) Structure and function of Vibrio cholerae Accessory cholera enterotoxin in presence of gold nanoparticles: dependence on morphology, *Biochimica et Biophysica Acta (General Subjects)* 1861, 977–986.

2. Mondal P K, Sarkar R, Chatterjee B K (2017) Response of Superheated Droplet Detector (SDD) and Bubble Detector (BD) to Interrupted Irradiations, *Nucl. Instr. and Meth.* A 857, 111–114.

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

(i) Chaired a session in 1st International Conference on Biomedical Science and Instrumentation (November 25, 2016), at SNBNCBS, Kolkata; (ii) Invited to deliver a lecture entitled “Our

Perception of Science", at One Day Seminar on Public Understanding of Science, organized jointly by ISNA, IAPQR and NASI held at Bose Institute on February 24, 2017.

Dr. Sanjay K. Ghosh

Senior Professor

Scientific Reports

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

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 an estimation 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. Here we make a first attempt at reparametrizing the model so as to reproduce these lattice data. We find excellent quantitative agreement for the equation of state. Certain discrepancies in the charge and strangeness susceptibilities as well as baryon-charge correlation still remain. We discuss their causes and outline possible directions to remove them.

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

In the present stud, the effects of magnetic fields on fluctuations and correlations in the hadron resonance gas model has been explored. We find significant changes in the fluctuations of net baryon number, electric charge and strangeness. This is also reflected in various fluctuation ratios along the freezeout curve.

Atmospheric Science: *In collaboration with Sanat Kumar Das Abhijit Chatterjee, Sibaji Raha*

A study of precipitation (rainwater) chemistry during the two consecutive summer monsoon seasons of 2013 and 2014 at a high altitude station (2200 m asl) at eastern Himalaya region (Darjeeling); a typical metropolitan urban location (Kolkata), and a rural environment near the Bay of Bengal (Falta) was conducted. The volume-weighted mean (VWM) concentration shows that total ionic composition was maximum over Kolkata (391 μeq l^{-1}) followed by Falta (204 μeq l^{-1}) and Darjeeling (64 μeq l^{-1}). 85% rain samples were alkaline over Kolkata, whereas, 55 and 65%

samples were acidic over Falta and Darjeeling respectively. Ca^{2+} was the most potential species to completely neutralize the acidity over Kolkata, whereas, NH_4^+ was the potential species to partially neutralize the acidity over Falta and Darjeeling. The deposition fluxes of anthropogenic and dust species over Kolkata was remarkably higher than Falta and Darjeeling. Anthropogenic and dust chemical species in rainwater were found to be dominant over Kolkata and Falta when the air masses passes from the polluted continental region. Rainwater acidity over Darjeeling was highest when air masses arrived from the Arabian Sea compared to air masses from the Bay of Bengal. Positive matrix factorization model was used for the source apportionment of the ionic species scavenged by rain. Comparable contributions of marine, dust, and anthropogenic sources were identified as major source over Kolkata. The major contributions were identified from marine and fossil fuel burning over Falta, whereas, marine, biomass/coal burning, ammonia from agricultural activities and domestic wastes were identified as the major sources over Darjeeling.

The paper presents the spatio-temporal variation of chemical compositions (organic carbon (OC), elemental carbon (EC), and water-soluble inorganic ionic components (WSIC)) of particulate matter (PM_{10}) over three locations (Delhi, Varanasi, and Kolkata) of Indo Gangetic Plain (IGP) of India for the year 2011. The observational sites are chosen to represent the characteristics of upper (Delhi), middle (Varanasi), and lower (Kolkata) IGP regions as converse to earlier single-station observation. Average mass concentration of PM_{10} was observed higher in the middle IGP (Varanasi 206.2 ± 77.4 μg m^{-3}) as compared to upper IGP (Delhi 202.3 ± 74.3 μg m^{-3}) and lower IGP (Kolkata 171.5 ± 38.5 μg m^{-3}). Large variation in OC values from 23.57 μg m^{-3} (Delhi) to 12.74 μg m^{-3} (Kolkata) indicating role of formation of secondary aerosols, whereas EC have not shown much variation with maximum concentration over Delhi (10.07 μg m^{-3}) and minimum over Varanasi (7.72 μg m^{-3}). As expected, a strong seasonal variation was observed in the mass concentration of PM_{10} as well as in its chemical composition over the three locations. Principal component analysis (PCA) identifies the contribution of secondary aerosol, biomass burning, fossil fuel combustion, vehicular emission, and sea salt to PM_{10} mass concentration at the observational sites of IGP, India. Backward trajectory analysis indicated the influence of continental type aerosols being transported from the Bay of Bengal, Pakistan, Afghanistan, Rajasthan, Gujarat, and surrounding areas to IGP region.

Publications :

A) Refereed Journals

1. Bhattacharyya Abhijit, Ghosh S K, Maity Soumitra, Raha Sibaji, Ray Rajarshi, Saha Kinkar and Upadhaya Sudipa (2017) Reparametrizing the Polyakov–Nambu–Jona-Lasinio model, *Phys. Rev.* D 95, 054005.
2. Bhattacharyya Abhijit, Ghosh S K, Ray Rajarshi, Saha Kinkar and Upadhaya Sudipa (2016) Polyakov- Nambu – Jona-Lasinio model at finite volume, *Europhys.Lett.* 116, no.5, 52001.
3. Bhattacharyya Abhijit, Ghosh S K, Ray Rajarshi and Samanta Subhasis (2016) Exploring effects of magnetic field on hadron resonance gas, *Europhys.Lett.* 115, no.6, 62003.

4. ALICE collaboration, T. Ablyazimov *et al*. (2017) Challenges in QCD matter physics --The scientific programme of the Compressed Baryonic Matter experiment at FAIR, *Eur. Phys. J.* A, 53: 60.

5. ALICE collaboration, J. Adam et al. (2017) W and Z boson production in p-Pb collisions at √sNN =5.02 TeV, *J. High Energ. Phys. 2017: 77.*

6. ALICE Collaboration, J. Adam et al. (2107) Determination of the event collision time with the ALICE detector at the LHC, *Eur. Phys. J. Plus,* 132: 99.

7. ALICE Collaboration; B. Chang et. al. (2017) ?-Meson production at forward rapidity in p–Pb collisions at √sNN = 5.02 TeV and in pp collisions at √s = 2.76 TeV., *Physics Letters B,* 768, 203.

8. ALICE collaboration, J. Adam et al. (2017) Charged-particle multiplicities in proton–proton collisions at √s =0.9 to 8 TeV, *Eur. Phys. J.,* C 77: 33.

9. ALICE collaboration, J. Adam et al. (2016) Jet-like correlations with neutral pion triggers in pp and central Pb–Pb collisions at 2.76 TeV, *Physics. Letters* B763, 238.

10. ALICE collaboration (2016) D-meson production in p-Pb collisions at √s=5.02 TeV and in pp collisions at √s=7 TeV, *Phys. Rev. C* 94, 054908.

11. Roy Arindam, Chatterjee Abhijit, Tiwari Suresh, Sarkar Chirantan, Das Sanat Kumar, Ghosh Sanjay Kumar, Raha Sibaji (2016) Precipitation chemistry over utban, rural and high altitude stations in Eastern Himalaya, *Atmospheric Research,* 181, 44.

12. Adak R P, Biswas S, Das S, Ghosal D, Ghosh S K, Mondal A, Nag D, Nayak T K, Patra T N, Prasad S K, Raha S, Sahu P K, Sahu S, Swain S (2016) Long term stability of GEM detectors, *Journal of Instrumentation,* 11, T10001.

13. ALICE collaboration, J. Adam et al. (2016) Correlated Event-by-Event Fluctuations of Flow Harmonics in Pb-Pb Collisions at √sNN=2.76??TeV, *Phys. Rev. Lett.*, 117, 182301.

14. ALICE Collaboration, J. Adam et al. (2016) easurement of transverse energy at midrapidity in Pb-Pb collisions at √sNN=2.76 TeV, *Phys. Rev. C,* 94, 034903 .

15. Sharma S K, Mandal T K, Srivastava M K, Chatterjee A, Jain Srishti, Saxena M, Singh B P, Sharma A, Adak A, Ghosh S K (2016) Spatio-temporal variation in chemical characteristics of PM_{10} over Indo Gangetic Plain of India, *Environ Sci Pollut Res,* 23: 18809.

Symposia/Conference Organized :

(I) Chairman, Organizing committee, Advance detectors for nuclear, high energy and astroparticle physics, Bose Institute, Kolkata, February 15 – 17, 2017; (ii) Coordinator of NESST-BASE 2016, a summer training programme for North-East students in basic sciences held at Bose Institute, Darjeeling during April 25 – May 7, 2016

Foreign Travel :

Participated in 27th CBM Collaboration meeting during April 11 – 15, 2016, at GSI, Darmstadt, Germany.

Dr. A. Chatterjee

Assistant Professor

Scientific Reports

Aerosol-Rain Interaction over Eastern Himalaya

The scavenging of aerosols by precipitation is one of the major mechanisms for maintaining a balance between the sources and sinks of atmospheric particles. The present study is based on the effect of physical characteristics of rain on the aerosol scavenging and acidity of rain samples over Darjeeling, a high altitude (2200 m asl), an Himalayan hill station. Simultaneous collection of PM10, PM2.5 and rain samples were done during monsoon (June to September), 2016 over Darjeeling. The average concentration of PM10 aerosol was found to be 11.4 ± 5.7µg m^{-3} varying between 5.7 µg m^{-3} and 25.5 µg m^{-3} whereas the concentration of fine mode aerosol (PM 2.5) was varying between 1.7 µg m^{-3} and 18.1 µg m^{-3} with an average of 7.3 µg m^{-3} in this entire study period

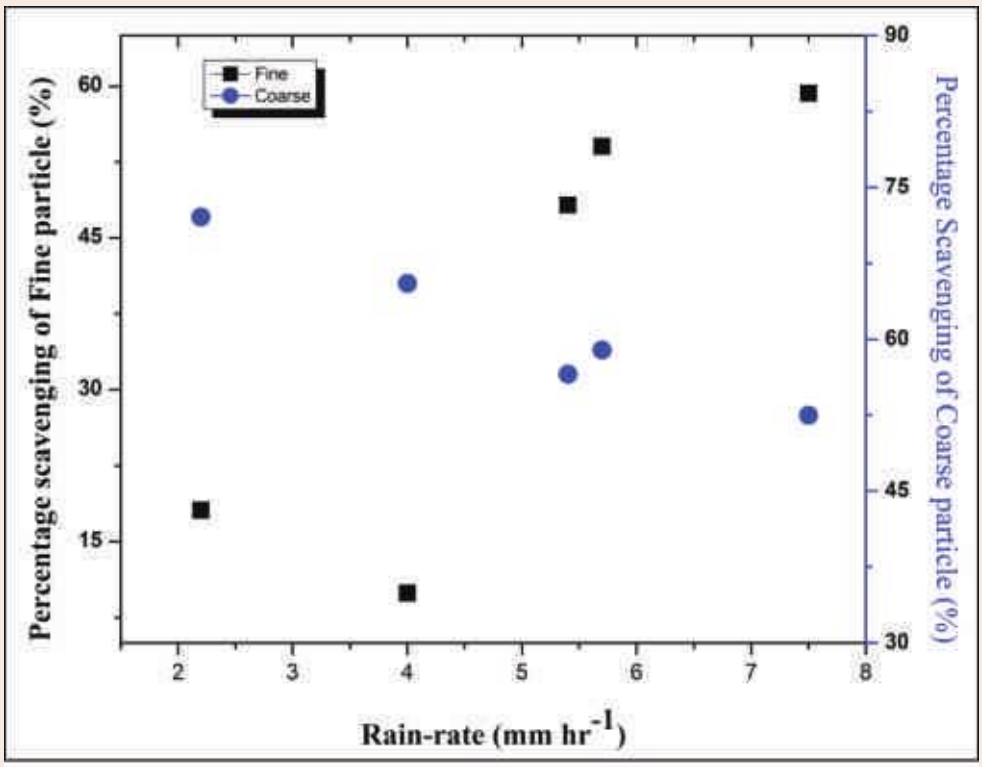


Fig 1: Aerosol scavenging by rain of different intensities

. SO_4^{2-} and Na^+ are found to be the most abandoned species in both fine and coarse mode during the study period.

Overall 60% of the total rain sample is found to be acidic in the study period. Long-term analysis of precipitation chemistry study (2013-2016) reveals no significant changes in major components of rainwater as well as pH. Very high Scavenging ratio was observed for NH_4^+ in both fine and coarse mode compare to other anthropogenic components indicates presence of gas phase ammonia during the study period. Further investigation on rainwater acidity reveals that scavenging of gaseous NH_3 has major contribution in neutralizing rainwater acidity over Darjeeling. Chemical composition of aerosol before rain event during rain event and after rain event indicate rain intensity played a major role in aerosol scavenging in fine mode and coarse mode aerosol. It was observed that high scavenging of coarser mode aerosol was observed in low rain-rate (< 5.0 mm hr^{-1}). On the other hand, fine mode aerosol scavenged well by higher rain-rate (> 5.0 mm hr^{-1}). Higher concentration of coarse mode sea-salt particles during rain indicates presence of low cloud in the sampling area. Scavenging and regeneration of fine and coarse mode aerosol were found to be different for different rain rate.

Long-term study of cloud condensation nuclei (CCN) activation of atmospheric aerosols over eastern Himalaya in India:

Cloud droplets in the atmosphere formed by condensation of supersaturated water vapor on aerosol particles. A subset of aerosol that provides the surface for this condensation is called Cloud Condensation Nuclei (CCN). The ability of aerosol to work as CCN is depends upon its size as well as its chemical composition. In our present study we have measured condensation nuclei (CN) and cloud condensation nuclei (CCN) over Darjeeling (27.03° N, 88.26° E), a high altitude hill station over eastern Himalaya (~ 2200 amsl) during dry seasons (2015-2016).

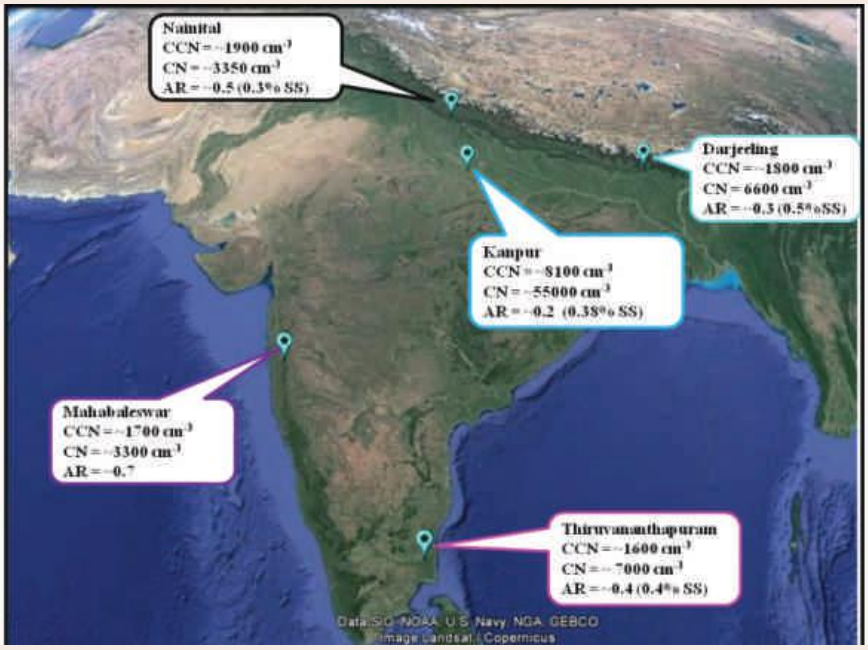


Fig 2: Aerosol-Cloud Condensation Nuclei activation over India

The number concentrations of CN ranged between 694 and 23,643 cm^{-3} with an average of 6563 ± 2160 cm^{-3} whereas that of CCN (at 0.5% super saturation) ranged between 262 and 13,382 cm^{-3} with an average of 1761 ± 856 cm^{-3} during the entire study period. Overall, 30–32% aerosols were observed to activate to CCN during winter and premonsoon whereas 24% activation was observed during postmonsoon. The diurnal variation of AR over Darjeeling shows higher values during late night to early morning hours (2100–0600 h) with the peaks at ~ 0400 h in all the seasons. Hygroscopicity parameter (k) calculated from CCN concentration at different supersaturation, reveals presence of aerosol particle with higher hygroscopicty during premonsoon. High CN and CCN were observed for the air masses arriving from northern, central and eastern part of IGP as well as arid and semi arid regions of west Asian countries during premonsoon. On the other hand, high CN and CCN during winter were observed for the air masses arrived from central and eastern part of IGP and Nepal. What we observed is that CN concentrations over Darjeeling were much higher (almost or more than double) than Nainital in western Himalaya all the dry seasons. Overall, we observed that submicron aerosols became more hygroscopic during their transport by external mixing during premonsoon, which in turn got activated to CCN whereas during winter aerosols from biomass burning became larger in size due to the coating of organic aerosols, trace gases and other soluble inorganic species which in turn activated to CCN.

Effect of Shifting Cultivation Activity over Eastern Ghat and Adjacent Places on the Air Quality of Kolkata :

The current practice of shifting cultivation in Eastern Ghat regions is an extravagant and unscientific form of land use. The evil effects of shifting cultivation are devastating and far-reaching in degrading the environment and ecology of this part. This has resulted in large-scale deforestation, soil and nutrient loss, and invasion by weeds and other species and massive deterioration of air quality in nearby and adjacent places. The study shows influence of downwind transported bio mass burning aerosols of Eastern Ghat and adjacent areas due to shifting cultivation activity on the air quality of a tropical urban atmosphere in Eastern India. During Pre-monsoon time particulate pollution remains less than post monsoon or winter over the whole IGP region because of the advection of the pollutant by intense solar heating. But due of the continuous flow of the transported bio mass burned aerosol, the concentration of aerosols over Kolkata was higher in April than May. The size segregated study reveals that the fine mode particles were high during burning period than the normal days. The aerosol mass distribution spectrum shows a bi modal distribution pattern over Kolkata in April with two distinguish peaks one in a fine mode and the other in coarse mode. On the other hand during May a trimodal distribution pattern was observed. Non-sea fine mode potassium shows a fourfold increased value during fire events than the normal days which clearly indicates the influence of bio mass burn plume over Kolkata. The other water soluble species like sulfate, nitrate, and ammonium also shows increase value during the fire events. Thick aerosol layers mixed with polluted dust and smoke was observed from CALIPSO which further more indicate the bio mass burned plume over the Kolkata. Presence of elevated amount of absorbing aerosols during the fire events was also observed from high value of Absorbing aerosol optical depth and UV-Aerosol Index. This furthermore clarifies the presence of soot and brown carbon over Kolkata during the fire events.

Polycyclic aromatic hydrocarbons in ambient air of Kolkata and Darjeeling

Polycyclic aromatic hydrocarbons (PAHs) are unpreventable byproducts of any kind of fuel and biomass combustion. Substantial impacts of PAHs have been documented on the ecosystem including human in terms of their cytotoxic effects including interruption of normal functioning of cell membrane and associated enzyme system, intensified inflammatory response, immunosupression, teratogenicity, carcinogenicity and mutagenicity to induce DNA-adduct formation. Hence, monitoring of the near surface atmospheric load of PAHs is utmost necessary. Therefore the current load of polycyclic aromatic hydrocarbons intrinsic to airborne fine (particulate aerodynamic diameter range 0.1 to 2.5 µm) and coarse (particulate aerodynamic diameter range 2.5 to 10 µm) particulate matter was measured systematically over Kolkata (c_{PAH} = ~ 90 ngm^{-3}) vis-à-vis over Darjeeling (c_{PAH} = ~ 20 ngm^{-3}), for the first time in the eastern Himalaya. Apart from meteorological influences, the socioeconomically and geographically different environments reflect prominently distinct air concentration values of PAHs over those stations. Additionally, the concentration values have been found to be comparable to other Indian cities and the atmospheric PAH load seems to be reduced in comparison to the earlier studies at Kolkata. However, 40–60% contribution of probable human carcinogens to the total-PAH measured in the current study raises the need to regulate the uncontrolled combustions and implementation of cleaner fuel in the public transport.

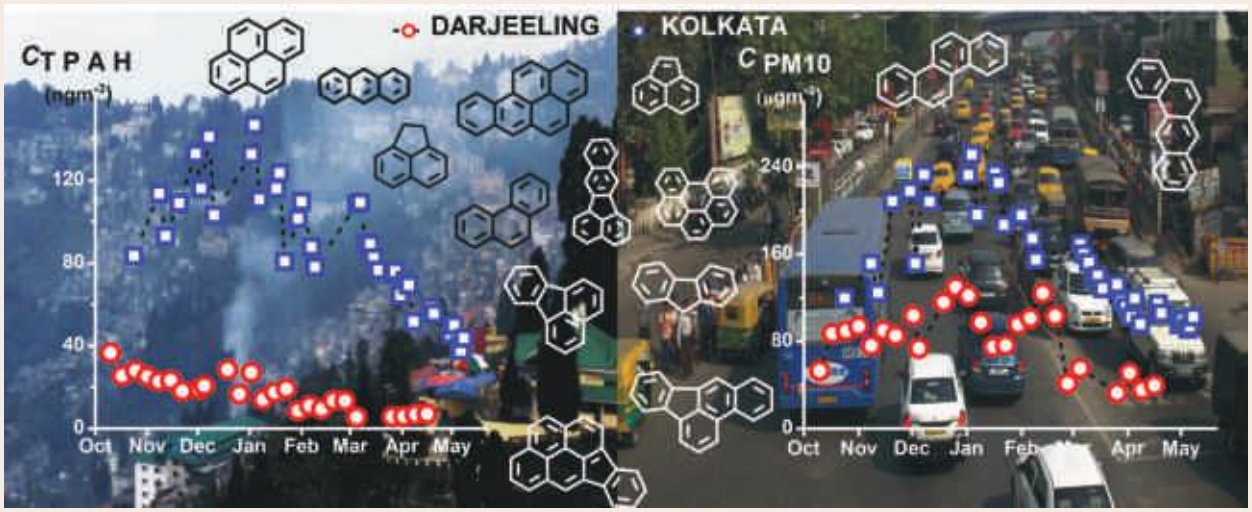


Fig 3: Hazardous carbonaceous aerosol pollutants over Kolkata and Darjeeling

Non-methane carbonaceous hazardous pollutants over eastern Himalaya

The first ever year-long study on atmospheric non methane volatile organic compounds (VOCs) and carbonyl compounds over Indian Himalaya was conducted where samples were collected from a high altitude station, Darjeeling (27.01°N, 88.15°E, 2200 masl). The major findings of the study are as follows:

Major VOCs and carbonyl compounds like benzene, toluene, ethylbenzene, xylene, acetone, formaldehyde and acetaldehyde over Darjeeling were found to be comparable and sometimes higher than some of the metro cities in India and other parts of the world. Both VOCs and carbonyl

compounds showed distinct seasonal variation with the maximum concentrations during postmonsoon followed by monsoon, winter ~ premonsoon. Surface reaching solar radiation played major role in photochemical production/degradation of VOCs and carbonyl compounds over Darjeeling. In spite of higher vehicular activities, photochemical degradation due to higher solar radiation flux reduced the atmospheric loading of VOCs and carbonyl compounds during premonsoon. On the other hand, low solar radiation along with higher vehicular activities helped in accumulating VOCs and carbonyl compounds during postmonsoon. Higher ozone formation potential suggests that more tropospheric ozone could be produced through the oxidation of volatile organic compounds during postmonsoon. Different sources of VOCs and carbonyls were identified over the study area, among them vehicular emission (gasoline and diesel exhaust), solvent evaporation, biogenic emissions from tea plantation and poor waste management system were the major sources of VOCs and carbonyl compounds over Darjeeling. The high atmospheric loading of VOCs and carbonyl compounds over Darjeeling is of a serious concern from the point of view of human health and sensitive ecosystem over this part of Indian Himalaya. Thus it is imperative to control vehicular pollution, solvent usage, adopt proper and scientific waste management system to mitigate these potentially carcinogenic pollutants over Darjeeling.

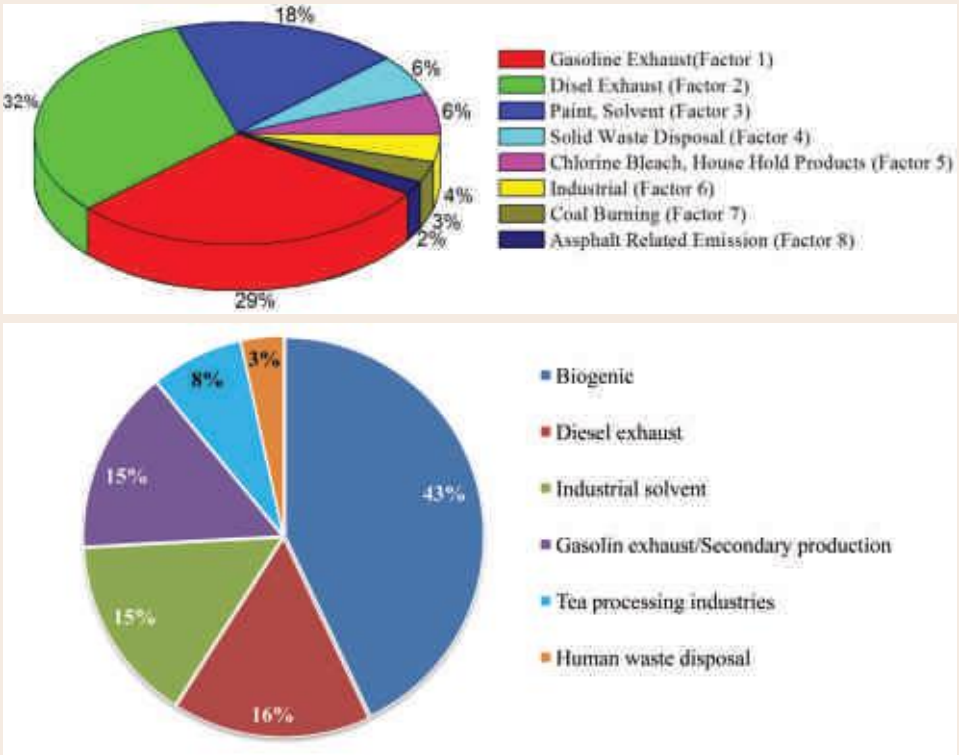


Figure. 4. Sources of (a) Volatile organic compounds and (b) carbonyl compounds over Darjeeling

The first ever long term study on trend of PM 2.5 and BC concentration and effects of various micrometeorological parameters and transportation patterns on the long term trend of these pollutants over an Himalayan hill station are summaries below:

The air quality over the hill station, Darjeeling is improving regarding fine aerosol and BC pollution over the study area. As a whole PM 2.5 concentration decreased 49% and BC concentration

decrease 34% from the year 2009 to 2015 at a rate of 0.2 $\mu gm^{-3}month^{-1}$ and 0.02 $\mu gm^{-3}month^{-1}$ for PM2.5 and BC respectively . Strong seasonality was observed for both PM2.5 and BC mass concentration. Maximum loading for both the pollutants ware observed during the month of March in the premonsoon season and minimum during the month of July/August (monsoon season). High atmospheric loading of PM2.5 and BC during premonsoon season was attributed to high vehicular emission and other anthropogenic activities related to peak tourist season along with favourable meteorological conditions. Heavy rainfall during monsoon season washed out the pollutants from the atmosphere causing minimum pollutant concentration during this season. Surface Wind Speed (WS) and Mixing Layer Depth (MLD) played a major role on pollutant concentration over Darjeeling. Significant positive correlation was found between these two parameters and pollutant concentration. High wind speed and elevated MLD helped pollutants to transport from long distant regions as well as from polluted foothill regions of Himalaya. A decreasing trend in ΔT, MLD and WS was the main meteorological effect to govern the pollutant concentration over the study area. Indo Gangetic Plane (IGP) and Nepal was identified as the main contributing source regions for both PM2.5 and BC. A change in transportation pattern was also observed that might also affect the pollution loading over the study area. The contribution from IGP and Nepal regarding pollutants transport was decreased where as local contribution on pollutants loading was increased. A decreasing trend of open burning over IGP and Nepal was also observed from MODIS satellite observation that might also have an effect on the decreasing pollutant transport from these source regions.

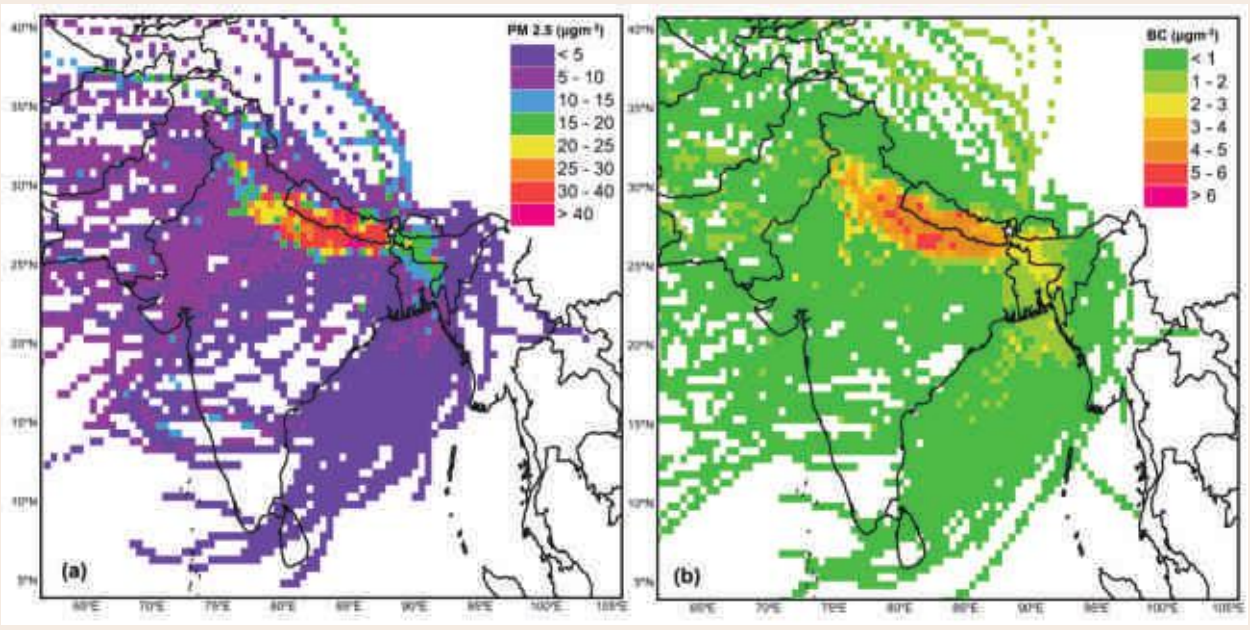


Figure 5. PM2.5 (a) and BC (b) contribution from different source regions towards Darjeeling, identified by CWT model analysis during the entire study period.

Himalayan ecosystem acts as a net sink of Co_2

To understand the impact of Indian subcontinent and its natural resources on the regional and global environmental changes, an integrated national environmental network Indoflux was

proposed few years back and has become operational sponsored by Indian Institute of Tropical Meteorology, Ministry of earth Sciences, Govt of India. This national comprehensive observation network integrates terrestrial, coastal and oceanic environments for the studies on exchange of greenhouse gases (GHG) for better understanding of the coupling of these different environments in India. Among the various sites under this national network in India, Bose Institute, has started monitoring and observational studies over a high altitude Himalayan forest in eastern India. The study on exchange of CO_2, H_2O and Energy fluxes is being carried out based on Flux-tower Eddy Covariance method erecting a 50 meter tall tower in a typical Himalayan sub-alpine coniferous forest. The observational site (27.04 ºN, 88.08 ºE) is situated at an altitude of 2286 m above mean sea level at eastern Himalaya in India. The forest vegetation is comprised mainly of Cryptomaria Japonica with the average height of 25 m. The site is in a highly complex terrain of Himalaya and situated in an absolute remote area with no anthropogenic activities and almost at ridge-top with an aerial distance of ~ 13 km from main Darjeeling Township.

The present study has investigated how the green house 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

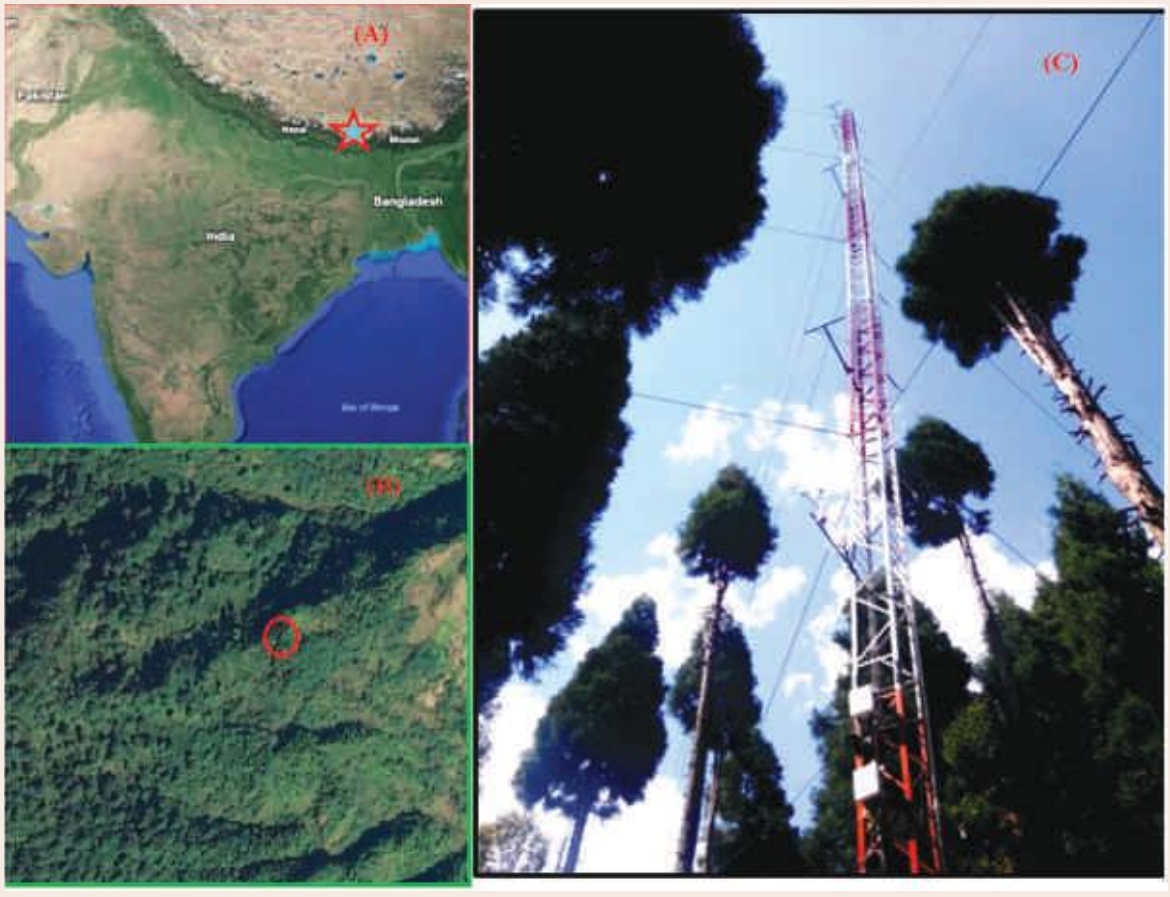


Fig 6: Flux Tower at Dhotrey Forest, Darjeeling

(27.04 ºN, 88.08 ºE) where we measured the concentrations and fluxes of CO_2 and H_2O vapour using eddy covariance method both above (38 m) and within (8 m) the canopy during March-April, 2015. The diurnal variations of the concentrations and the eddy fluxes of CO_2 and H_2O vapour at both the heights along with the vertical profile of CO_2 were measured. We have also examined the CO_2 fluxes from the soil surface of the forest. Investigation was also made on how the eddy and soil fluxes of CO_2 respond to the precipitation. Overall, during the entire summer season the gross primary productivity (GPP) and ecosystem respiration (RE) were calculated as -838 g CO_2 m^{-2} and +181.5 g CO_2 m^{-2} respectively and thus the net ecosystem exchange (NEE) becomes -656.5 g CO_2 m^{-2} suggesting that the large evergreen coniferous forest at eastern Himalaya in India acts as a net sink of CO_2 during summer.

Grants-in-Aid Schemes :

Title of the Scheme	Schemes funded by
As Principal Investigator of one program and as co-PI of other programs Study of Cosmic ray interactions and Cosmic Ray – Aerosol – Cloud connection in the context of regional climate change	DST, Govt. of India
As Principal Investigator Study on Biosphere-Atmosphere Exchange of Carbon dioxide, Water Vapor and Energy in a Tropical High Altitude Forest Canopy at Eastern Himalaya, India	MoES, Govt of India
As Principal Investigator National Carbonaceous Aerosol Program (NCAP)	MoEFCC, Govt of India

Publications :

1. Roy A, Chatterjee A, Sarkar C, Das S K, Ghosh S K and Raha S (2017) A study on aerosol-cloud condensation nuclei (CCN) activation over eastern Himalaya in India. Atmospheric Research (IF:3.377), 189, 69-81.
2. Sen A, Ahammed Y Nazeer, Mansour Alghamdi A, Banerjee T, Bhat Mudasir Ahmad, Chatterjee A, Choudhuri A K, Dhir A, Das T, Gadi R, Ghosh S K, Khan A H, Kumari K Maharaj, Kuniyal J C, Lakhani A, Naja M, Pal D, Pal S, Ramshoo S, Rashid I, Saikia P, Shenoy D M, Sridhar V, Verma N, Vyas B M, Saxena M, Sharma S K, Sharma A and Mandal T K (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 (IF: 3.459)*, 154, 200-224.

Dr. Supriya Das

Associate Professor

Scientific Reports

Design and development of Coomon Readout Unit (CRU) for the ALICE Experiment : with Sanjoy Mukherjee; External collaborators : Tapan K. Nayak, Shuaib Ahmed Khan and Zubin Mitra (VECC), Amlan Chakraborti and Rourab Pal (University of Calcutta)

CRU-DEVELOPMENT :

The CRU will be used by all the upgraded detector systems to read out detector data and it will store the data in the memory of the server through two PCIE Gen.3 x8 i.e. PCIe Gen3 x16 performing DMA.

There are many chips on CRU card itself and also, detector specific ASICs on FEE board that are to be configured before readout. The PCIE-BAR interface has been used for configuration.

The CRU uplink related with PCIe-DMA and downlink related with PCIe-BAR were evaluated and custom logic has been developed as per CRU requirements. The work done on both the links is described below:

CRU-UPLINK/PCIE-DMA:

The DMA performance has been measured on hardware as per CRU requirment and found enough (~ 49 Gbps, requirement is 45 Gbps) to handle incoming data throughput. The firmware as well as software (application only not the driver) has been developed to validate the DMA performnce. This perfromance has been evaluted without checking the data consistancy. The following paper has been published related with work done on this stage.

The interfacing with cru user logic and pcie dma engine has been done with the aid of FIFO like buffer memory to maintain the data consistancy. The data consistancy has been checked for the entire path from user logic to read out at server end. The system has been stressed well enough by emulating the random data flow. The idle time i.e. the sum of inherent latency of DMA engine and PCIe busy time, is measured to tune the buffer size. The idle time is an important parameter that will affect CRU data flow and as well as event building in O2. Changes has been done on user logic related with DMA to improve the DMA performnce (49 Gbps -> 53 Gbps) as well minimize the software dependancycy on idle time. The following paper has been written related with work done on this stage.

The CPU usage of processes (software related) involved in movement of data from CRU to GRID, are being evaluated by O2 to utilize CPU cores efficiently. It was found that the process that moves the data from CRU to the server through PCIe-DMA interface has almost 100% CPU usage. A new software model has been proposed to reduce the CPU usage. The necessary user logic has been developed in PCIe-DMA module to use that model and as well as further user logic has been

developed to merge/split detctetor data in readout server as per O2 requirement. Changes has been done on user logic related with DMA to improve the DMA performnce(53Gbps -> 55 Gbps) as well minimize the software dependancycy on idle time. The work done on this stage submitted as abstarct for TWEEP 2017 and has been accepted.

CRU-DOWNLINK/PCIE-BAR:

The on board components are mainly related with optical modules through which CRU communicates with detectors and trigger system and clock modules used to generate clock with very low jitter for CRU-GBT (Giga Bit Transceiver) module and also sensor modules that will provide board and die temperature, power consumption of the card. The monitoring and configuration of those modules have been done using I2C interface and PCIe-BAR interface is used by the server to read/write data from/to CRU. Every chip has multiple registers that have been configured as per CRU requirement.

The module inside CRU which controls on detector ASICs is FEE-SC (slow control module). The FEE-SC module generates HDLC command frame based on configuration data received over PCIe-BAR and send it to GBT-SCA for the configuration of on detector ASICs. The custom logic has been developed to make HDLC frame from configuration data and embedded the same inside GBT frame. The bi-directional communication of CRU slow control module and GBT-SCA chip has been tested using VLDB and Intel Arria 10 dev kit. The following paper has been written related with work done on this area.

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*

The nuclear reactions that destroy ^{7}Be deserve special attention in the study of the cosmological lithium problem. Accurate measurements are required before one can invoke solutions beyond nuclear physics, particularly the newly conjectured light electrically neutral particles X that may have substantial interactions with nucleons. We continued our preparation for the planned experiment at HIE-ISOLDE, CERN, Geneva, Switzerland, measuring the destruction of ^{7}Be through the resonance excitation of ^{7}Be(d,p)^{8}Be* (IS 554). We would use the scattering chamber having sets of strip detectors covering a large angular range, installed at one of the beamlines of the HIE-ISOLDE facility. Substantial work has been carried out in installing NPTool, a framework based on Geant4 and ROOT for simulation and analysis of nuclear physics experiments. The simulations using NPTool as well as DWBA calculations for the reaction ^{7}Be(d,p)^{8}Be* using the code FRESCO have been carried out at Bose Institute.

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

Breakup reactions play a prominent role in loosely bound nuclei. In order to study the cosmological lithium problem the ^{7}Li production channel also deserves attention. This in turn is related to the ^{7}Be production channel through the radiative capture reaction ^{3}He + ^{4}He → ^{7}Be + $\tilde{\gamma}$. This 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.

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

Analysis of the data for the n-p pairing experiment (e644) at the rare isotope facility GANIL, Caen, France was continued. The aim of this experiment is to study two nucleon n-p transfer reactions on two nuclei, a mid-shell nucleus ^{48}Cr, a candidate for n-p pairing correlations, and the doubly magic nucleus ^{56}Ni which will not show any pairing effects. On both these nuclei we measured (p,^{3}He) and (d,α) reactions in order to investigate the competition between T=1 and T=0 pairing and probe n-p pairing. We are carrying out a part of the data analysis at Bose Institute in the NPTool framework in collaboration with IPN, Orsay, France. Detailed analysis have been carried out to calibrate the double sided strip and CsI detectors of MUST2 in e644 using α-source. A preliminary analysis shows that n-p pairing in ^{56}Ni is mainly of isovector type.

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

Experimental advancements in the field of nuclear physics allow us nowadays to study exotic unstable and even unbound nuclei. Theoretically, it is very difficult to tackle the unbound states by conventional methods. Earlier, we used a very effective technique to detect low-lying broad resonances of weakly bound nuclei. Its success encouraged us to apply it effectively for unbound nuclei like ^{15}Be. We used the theoretical procedure of supersymmetric quantum mechanics (SQM) to study their resonance states. We could reproduce the unbound state energies without any modification of our constructed density dependent M3Y (DDM3Y) microscopic potential. Our procedure confirmed the existence of 5/2^{+} state and also reproduced the experimentally predicted unbound resonance energy of 1.8 MeV. The generated potential, depending on a suitably chosen parameter, is strictly isospectral with the original DDM3Y potential although the two have widely different shapes. This fact could also be utilized to calculate other observables of ^{15}Be.

Publications :

1. Dutta S K, Gupta D, Saha Swapan K (2016) Study of Unbound States of ^{15}Be using Supersymmetric Quantum Mechanics, *arXiv:1703.09448v1 [nucl-th]*

Symposium publication :

1. Dutta S K, Gupta D, Saha Swapan K (2016) Study of unbound states of ^{15}Be using supersymmetric quantum mechanics, *Proceedings of the DAE-BRNS Symposium on Nuclear Physics* 61, 80
2. Sinha M, Gupta D, Saha Swapan K (2016) Resonance excitation in ^{7}Be + d reaction to study the cosmological lithium problem, *Proceedings of the DAE-BRNS Symposium on Nuclear Physics* 61, 886

Grants-in-Aid Schemes :

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

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

Visited and carried out collaborative research at the Institut de Physique Nucleaire, Orsay, France, September 21 – 25, 2016 for experiment e644 at GANIL; at CERN, Geneva, Switzerland, September 25 – October 5, 2016 for upcoming experiment IS554 at HIE-ISOLDE, CERN. Dr. M. Sinha (RA) presented a poster titled "Resonance excitation in ^{7}Be + d reaction to study the cosmological lithium problem" at the 61st DAE-BRNS Symposium on Nuclear Physics at SINP, Kolkata, December 5 – 9, 2016 and was awarded as one of the best poster presentations.

Dr. Dipankar Home

Senior Professor and Coordinator

Scientific Reports

Studies on Foundational Problems of Quantum Mechanics

For multilevel spin systems, the robustness of the quantum mechanical (QM) violation of macrorealism (MR) with respect to coarse-grained measurements has been investigated using three different necessary conditions of MR, namely, the Leggett-Garg inequality (LGI), Wigner's form of the Leggett-Garg inequality (WLGI), and the condition of No-Signaling in Time (NSIT). Importantly,

the QM violations of all these persist in that limit even for *arbitrary* unsharp measurements. The results clearly demonstrate that classicality does not emerge in the asymptotic limit of spin, whatever be the unsharpness and degree of coarse graining of the measurements.

In the weak measurement (WM) scenario involving weak interaction and postselection by projective measurement, the empirical significance of weak values is manifested in terms of shifts in the measurement pointer's mean position and mean momentum. In this context, a general quantitative treatment has been presented in our work by taking into account the hitherto unexplored effect of correlations among the pointer degrees of freedom which pertain to an arbitrary multidimensional preselected pointer state. The particular relevance of this analysis has been analysed in the case of sequential weak interactions.

Publications :

1. Kanjilal S, Muralidhara G and Home D (2016) Manifestation of pointer-state correlations in complex weak values of quantum observables; *Physical Review* A 94, 052110. Impact Factor: 2.765
2. Mal S, Das D and Home D (2016) Quantum mechanical violation of macrorealism for large spin and its robustness against coarse-grained measurements; *Physical Review A* 94, 062117. *Impact Factor: 2.765*

Grants-in Aid-Schemes :

Title of the Scheme	Schemes funded by
(Jointly with Prof. Archan S. Majumdar of SNBNCBS, Kolkata as PI) Fundamental aspects of quantum theory and quantum information: a multidisciplinary approach	DST
(Jointly with Prof. Alexandre Matzkin of Université de Cergy-Pontoise, France as Principal Investigator, and Prof. Urbasi Sinha of Raman Research Institute, Bangalore as another Co-PI) 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 Report

High Energy Astrophysics and Computational Astrophysics

Investigating the region of 3C 397 in High Energy Gamma rays: *with Pooja Bhattacharjee as external collaborator*

We have investigated the supernova remnant (SNR) 3C 397 and its neighbouring pulsar PSR J1906+0722 in high energy gamma rays by using nearly six years of archival data from the Large Area Telescope on board Fermi Gamma Ray Space Telescope (Fermi-LAT). The offpulse analysis of gamma-ray flux from the location of PSR J1906+0722 reveals an excess emission which is found to be very close to the radio location of 3C 397. Here, we present the preliminary results of this gamma-ray analysis of 3C 397 and PSR J1906+0722.

Constraints on dark matter models from the observation of Triangulum-II with the Fermi Large Area Telescope: with *Sayan Biswas, Pooja Bhattacharjee as external collaborator*

Triangulum-II, a newly discovered dwarf spheroidal galaxy, is a strong candidate for the indirect search of dark matter through the detection of γ-ray emission that could originate from pair-annihilation of the weakly interacting massive particles (WIMPs). We here report on the analysis of almost seven years of Fermi Gamma-Ray Space Telescope data of Triangulum-II which was taken during its all sky survey operation mode. No excess γ-ray emission has been detected above 100 MeV from Triangulum-II.

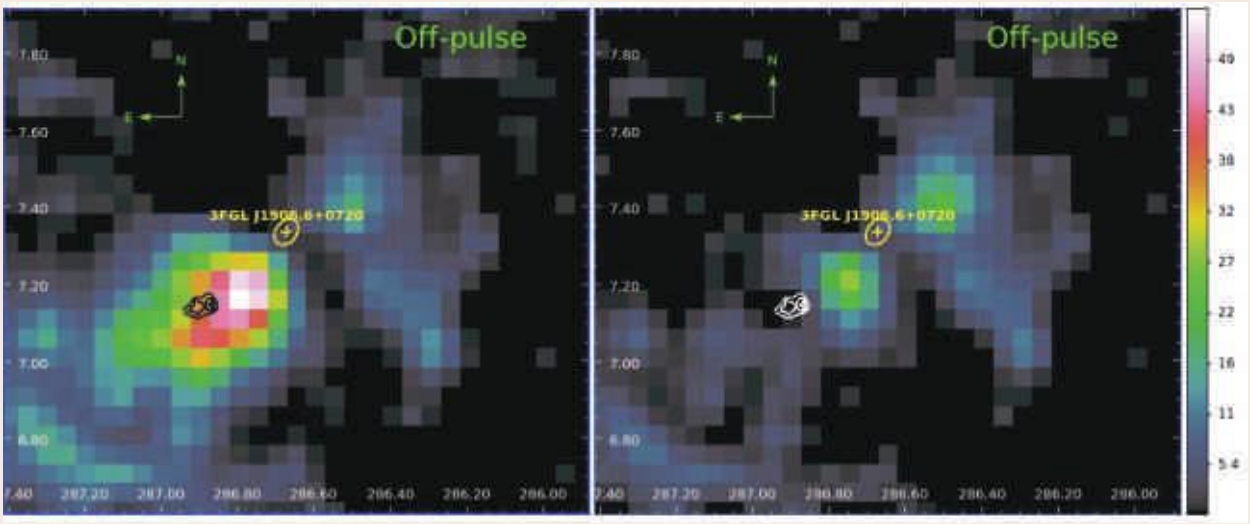


Figure 1: A $10^{\circ} \times 10^{\circ}$ residual TS map showing the analysis region around the location of 3FGL J1906.6+0720 / PSR J1906+0722. The excess emission near 3C 397, seen in the Left panel, has been included in the background model of the Right panel. Contours represent the *ROSAT* counts and yellow cross and the circle correspond to the best-fit position and error of 3 FGL J1906.6+0720, respectively.

We derive the upper limits on γ-ray flux assuming both the power-law spectra and the spectra related to WIMP annihilation. In this work, we have considered several theoretical WIMP (neutralinos here) models envisioning both thermal and non-thermal production of the WIMPs, and put limits on the pair-annihilation cross-section of the WIMPs to constrain the parameter space related to those theoretical models.

A 2.5-dimensional viscous, resistive, advective magnetized accretion outflow coupling in black hole systems: A higher order polynomial approximation:

The correlated and coupled dynamics of accretion and outflow around black holes (BHs) are essentially governed by the fundamental laws of conservation as outflow extracts matter, momentum and energy from the accretion region. Here we analyzed a robust form of 2.5-dimensional viscous, resistive, advective magnetized accretion-outflow coupling in BH systems. We solve the complete set of coupled MHD conservation equations self-consistently, through invoking a generalized polynomial expansion in two dimensions. We perform a critical analysis of accretion-outflow region and provide a complete quasi-analytical family of solutions for advective flows. We obtain the physical plausible outflow solutions at high turbulent viscosity parameter α ($\geq$ 0.3), and at a reduced scale-height, as magnetic stresses compress or squeeze the flow region. We found that the value of the large-scale poloidal magnetic field $\overline{B_p}$ is enhanced with increasing geometrical thickness of the accretion flow. On the other hand differential magnetic torque $\left(-r^2\overline{B_\varphi B_z}\right)$ increases with the increase in $M\ \overline{B_p}$, $-r^2\overline{B_\varphi B_z}$as well as the plasma beta B_P get strongly augmented with the increase in the value of α, enhancing the transport of vertical flux outwards. Our solutions indicate that magnetocentrifugal acceleration plausibly plays a dominant role in effusing out plasma from the radial accretion flow in moderately advective paradigm which are more centrifugally dominated, however in strongly advective paradigm it is likely that the thermal pressure gradient would play a more contributory role in the vertical transport of the plasma (Shubhrangshu Ghosh).

Spherical accretion in giant elleptical galaxies: Implications for AGN Feedback

Accreting supermassive black holes at the center of the active galaxies release huge amount of energy into the surrounding in both radiative and kinetic forms. The interaction between this 'feedback' and the ambient medium can have strong impact on host galaxy, and this AGN feedback is now thought to play a major role in the galactic evolution. For low-luminous, low-excitation radio sources, which mostly dominate the local radio galaxy population and the central region of the cool core clusters, and which are generally hosted by massive elliptical galaxies, most of the energy of their active nucleus is released in the kinetic form via radio emitting jets. This kinetic feedback (or radio mode feedback) prevents the intercluster gas from radiatively cooling and collapsing on to the host galaxy, thus keeping the surrounding gas hot. This hot gas has been widely argued to be the fuelling source of these massive ellipticals through quasi-spherical, Bondi type accretion. The radio-AGN feedback cycle is now thought to play a key role in shaping the late evolution of massive galaxies in the present-day universe. A complete study of Bondi type

spherical-accretion in giant elliptical galaxies and its implication on AGN feedback cycle has been performed. Incorporation of the effects of rotational angular momentum of the accretion disk and also of its viscosity is presently under investigation (Sananda Raychoudhuri, Shubhrangshu Ghosh and P. Joarder).

High-Resolution, Multidimensional Numerical methods for Wave Propagation problems in Hydrodynamics and Magnetohydrodynamics

One dimensional and two dimensional computer simulation programs in CFD have been written that are based on finite volume TVD schemes. These programs are now being tested on various benchmark cases suggested by earlier authors that includes highly relativistic fluid flows. Rogorous testing of several publicly available multidimensional, nonrelativistic CFD and MFD codes have also been undertaken. We now consider several astrophysical and solar-terrestrial problems that are to be solved with the computer codes mentioned above (Sananda Raychoudhuri, Kaushik Naskar and P. Joarder with external collaborators).

Publications :

1. Biswas S, De J N, Joarder P, Raha S and Syam D (2017) Multifragmentation model for the production of astrophysical strangelets. *Phys. Rev. C*, 95, 045201.
2. Bhattacharjee P , Majumdar P, Ergin T, Saha L and Joarder P (2017), Investigating the region of 3C 397 in high energy γ-rays (MS ID: IAU-17-IAUS331-0190.R1), in: A. Marcowith, G. Dubner, A. Roy, A. Bykov and M. Renaud (eds.), *SN1987A: 30 Years Later*, Proceedings of the International Astronomical Union (IAU), Cambridge University Press (in Press).
3. Biswas S, Bhattacharjee P, Majumdar P, Das S, Das M and Joarder P (2017), Constraints on dark matter models from the observations of Triangulum-II with the *Fermi* Large Area Telescope, *arXiv: 1705.00426.v2 [astro-ph]* (under revision in peer reviewed journal).
4. Ghosh S (2017) A 2.5-dimensional viscous, resistive, advective magnetized accretion-outflow coupling in black hole systems: A higher order polynomial approximation. *Research in Astronomy and Astrophysics* (in Press), *arXiv: 1611.02414 [astro-ph]*.

Participation in Conferences/Symposium/Workshops and invited Talks Delivered at Various Organizations :

Group Members:

Pooja Bhattacharjee (JRF) participated in "Supernova 1987A: 30 years later (IAU Symposium 331)" held at Saint-Gilles-les-Bains, La Reunion Island, France during February 20 – 24, 2017 with a poster presentation. She also participated in the 35th *Meeting of the Astronomical Society of India (ASI)* at the Birla Institute of Scientific Research at Jaipur, India, during March, 6 – 10, 2017 with an oral presentation.

Sayan Biswas (SRF) and Pooja Bhattacharjee (JRF) presented a scientific poster titled "Indirect dark matter search using FERMI gamma ray data of low surface brightness galaxies" at the XXXIV meeting of ASI at the Kashmir University, Srinagar during May 10 – 13, 2016.

Shubhrangshu Ghosh delivered a scientific talk titled “Black hole accretion in magnetohydrodynamical paradigm: from X-ray binaries to AGNs” at the 'National seminar on recent development in plasma physics' at the Centre for Plasma Studies, Jadavpur, Kolkata, India.

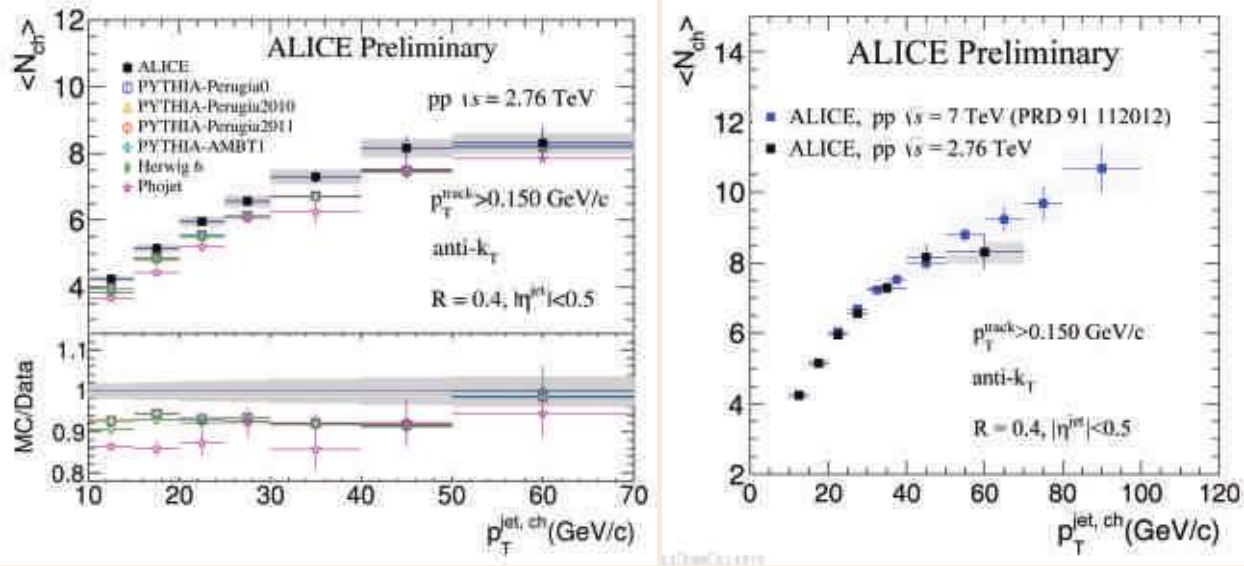
Dr. Sidharth Kumar Prasad

Assistant Professor

Scientific Reports

Measurements of charged jet cross sections and properties 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)*

Jets are produced in interactions with large momentum transfer in hadronic and nucleon- nucleon collisions. The production cross-section of jets and its associated properties can be calculated using the framework of perturbative quantum chromodynamics (pQCD). The jet measurements in hadronic collisions provide a solid testing ground for the pQCD calculations. Jets are important probes to understand the medium properties in high-energy nucleus- nucleus collisions where a thermalized system of quarks and gluons (QGP) is formed. Measurements in hadronic collisions are used as a baseline for similar measurements in nucleus-nucleus collisions to make final



Preliminary results are shown in figures above where in the left figure we show mean number of charged particles in a jet ($< N_{ch} >$) as a function of jet p_T compared to that obtained from simulations. In the right figure we show energy dependence of $< N_{ch} >$.

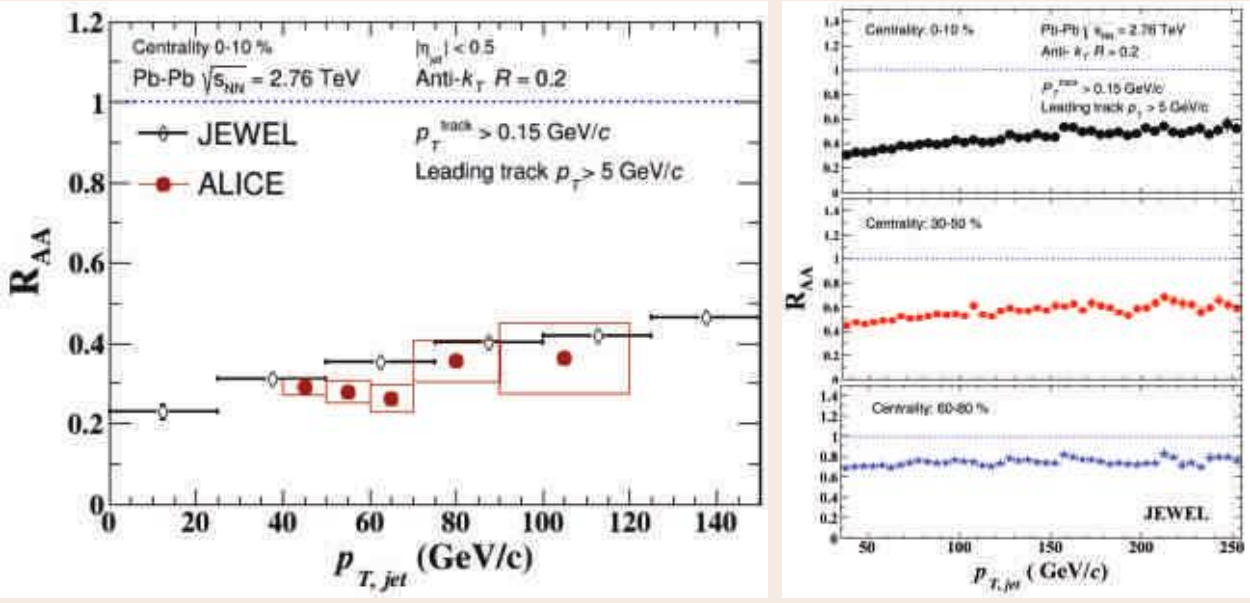
conclusions. Presently we are working on measurements of charged jet cross-sections and properties in pp collisions at 2.76 TeV. The main outcome of the analysis in terms of preliminary results are already presented and published as conference proceeding (link: https://arxiv.org/abs/1702.07646) and we are working on finalizing it towards the publication.

Energy dependence of integrated suppression factor from R_{AA} and R_{CP} in relativistic heavy ion collisions : *In collaboration with Rathijit Biswas, Supriya Das, External Collaborators: Sumit K. Saha, Sumit Basu, Souvik P. Adhya, Tapan K. Nayak (VECC, Kolkata)*

Partons produced in early stage of the collisions, while passing through the medium, loose energy via multiple interactions and gluon radiations. This leads to the modification of the p_T spectra of the final state hadrons for A-A collisions with respect to p-p collisions, key being the Nuclear modification factor R_{AA} and R_{CP}. Based on the available results of $R_{AA}(p_T)$ and $R_{CP}(p_T)$ measurements from various experiments, we have calculated the p_T integrated suppression fraction (ISF) and studied this as a function of collision energy for central collisions. The values of ISF have been estimated for Pb-Pb collisions at 5.02 TeV at the CERN Large Hadron Collider. The preliminary results as shown in the figures below, are presented in the DAE-NP-2016 conference recently and the work is ongoing.

Studying medium modification of jet using Jet Evolution With Energy Loss (JEWEL) model: *in collaboration with Rathijit Biswas, Dr. Subikash Choudhury, Dr. Supriya Das*

The modification of hadron yields and jet production cross section in central heavy ion collisions at high p_T, compared to number of “binary collision” scaled pp reference has now been established as

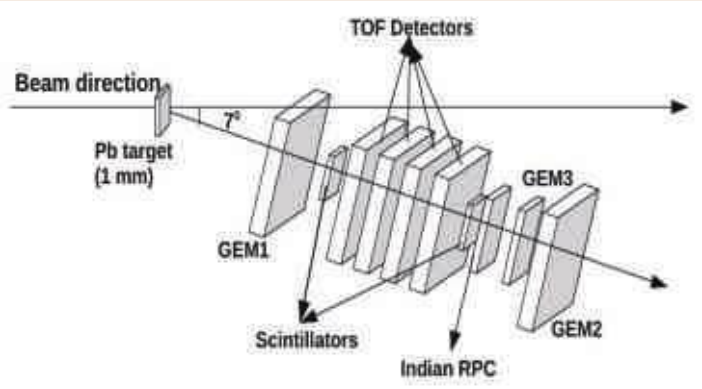


Figures above show $R_{AA,jet}$ as a function of jet p_T obtained from JEWEL compared to ALICE data (left) and their centrality dependence (right).

a compelling evidence of energy loss of hard scattered partons when propagating through dense medium of partonic constituents or the Quark Gluon Plasma (QGP). The modification is quantified in terms of jet nuclear modification factor $R_{AA,jet}$. We have studied the modification of jet production cross section in different centrality of Pb-Pb collisions at 2.76 TeV centre of mass energy within the framework of a model that implements jet evolution with energy loss (JEWEL).

Analysis of the test data of real size GEM prototype for CBM- Much: *in collaboration with D. Nag, External Collaborators from VECC Kolkata: Ajit Kumar, A. K. Dubey, J. Saini , V. Singhal, P. P. Bhaduri, E. Nandy, S. Chattopadhyay (CBM Collaboation)*

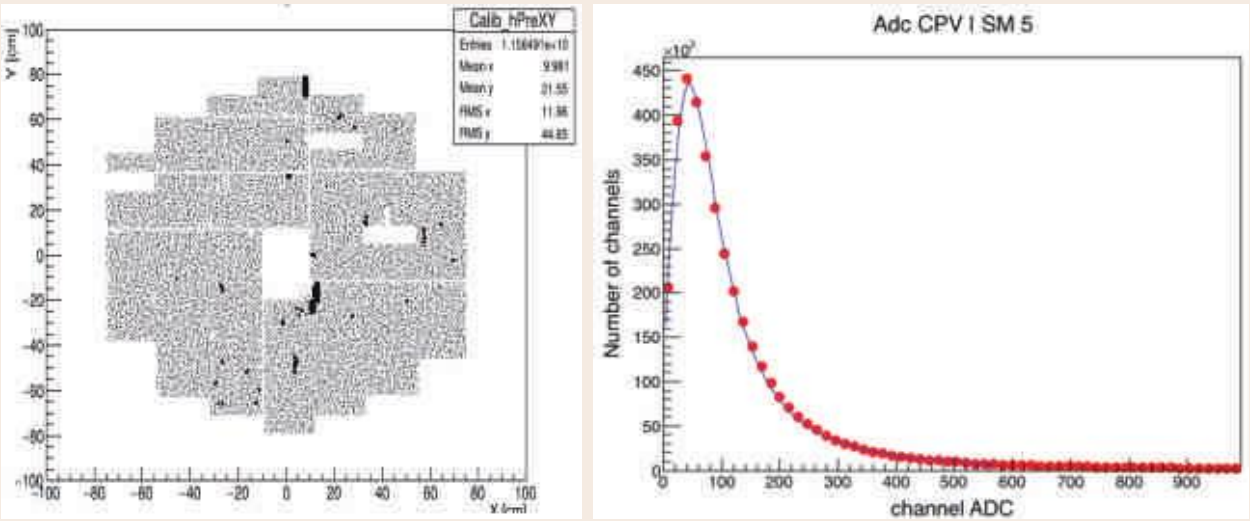
A Triple GEM Muon Chamber (MuCh) detector, built in India, will be installed in the experiment for Muon detection. The CBM experiment is designed to handle unprecedented interaction rates (10 MHz) of Au + Au collisions in an energy range of up to 11 AGeV. The Muon Chamber (MUCH) system consists of layers of instrumented muon absorbers with detector stations sandwiched between them. A trapezoidal shaped, large size, Gas Electron Multiplier (GEM) detectors would be employed to perform the job of high rate tracking in the first few stations. In this regard, we have tested real-size prototypes of MUCH chambers in Pb + Pb collisions at CERN SPS. For the first time, almost full module acceptance was populated with realistic self-triggered electronics. The entire active area consisting of about 1900 readout pads having progressively increasing sizes was 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 results is underway.



Figures above show the schematic of the test setup (left) and real experimental setup for the test beam (right).

PMD Data Quality Assurance and Physics Analyses: *In collaboration with Rathijit Biswas, External Collaboration: Sinjini Chandra (VECC, Kolkata)*

Photon Multiplicity Detector (PMD) is an Indian contribution to the ALICE experiment at LHC, CERN. PMD is designed, fabricated and tested at VECC in collaboration with other ALICE India universities/institutes and commissioned in ALICE experiment at the LHC CERN. During the past several years of LHC running PMD has collected millions of events for pp, pPb and PbPb collisions at various centre-of-mass energies (pp @ 0.9, 2.76, 5.02, 7, 8 and 13 TeV; p-Pb @ 5.02 and 8.16 TeV and Pb-Pb @ 2.76 and 5.02 TeV). 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, normalization of gain variations within the module etc.



Figures above show 2D scatter plots of hits in PMD pre-shower plane (left) and channel ADC distribution fitted to a landau distribution (right).

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

In the Compressed Baryonic Matter (CBM) experiment at the upcoming Facility for Antiproton and Ion Research (FAIR) facility in Darmstadt, India (Variable Energy Cyclotron Centre, Bose Institute and other collaborating institutes) is building a GEM based muon detector (Muon Chamber (MUCH)) and its associated readout. MUCH consists of alternating layers of six absorbers and detector stations. Each full size GEM module uses 15 Front End Electronic (FEE) boards to collect the signals from the detector. These boards are sensitive to temperature, the operating range being ~20-250C. The heat dissipated by FEE boards is estimated to be ~90 W per GEM module. This heat is to be continuously dissipated out to keep the ambient temperature within the desirable range. We are designing water based cooling system to achieve this. Using a small prototype 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 with satisfactory performance. The work is ongoing for the actual setup for the real experiment where there will be several such cooling modules to be integrated.

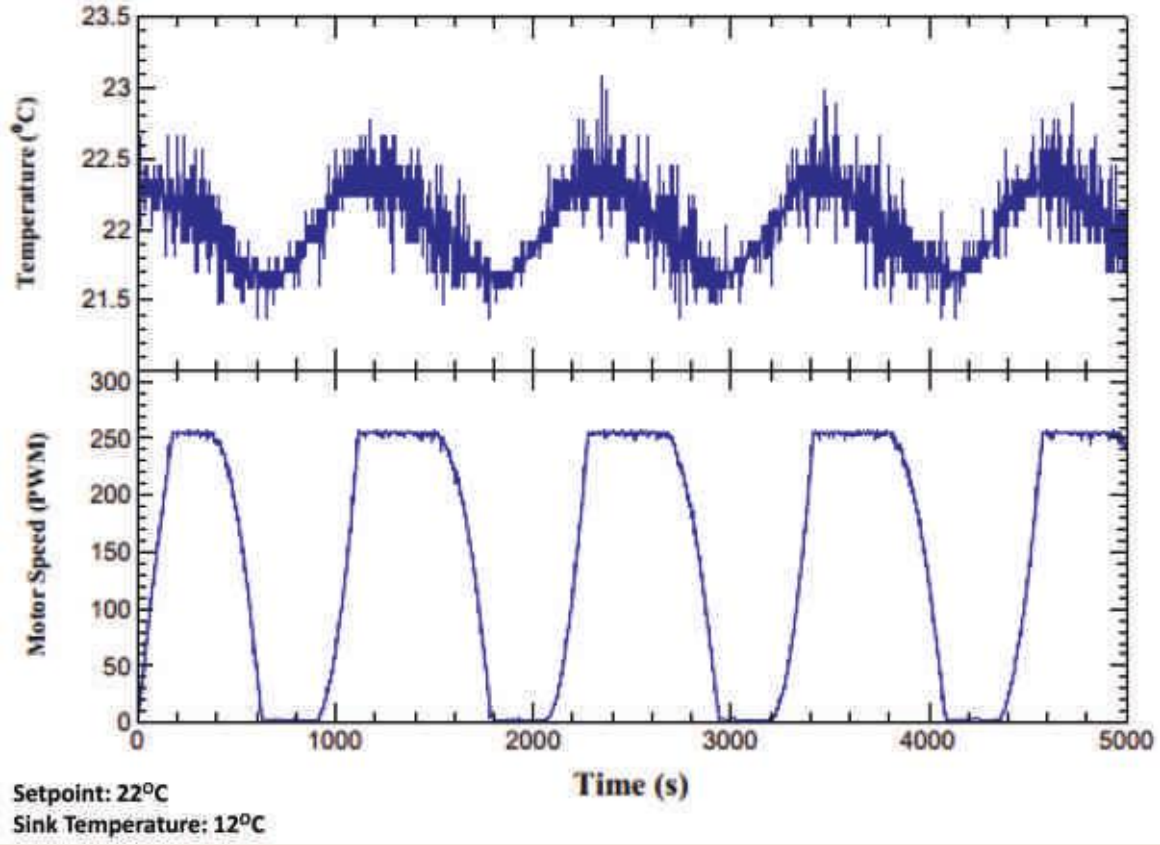


Figure above show the variation of temperature and motor speed as a function of time.

Publications :

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)

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2. J. Adam et al. (ALICE Collaboration) (2017) Determination of the event collision time with the ALICE detector at the LHC. Eur. Phys. J. Plus: 132: 99.
3. J. Adam et al. (ALICE Collaboration) (2017) φ-meson production at forward rapidity in p-Pb collisions at $\sqrt{s_{NN}}$ = 5.02 TeV and in pp collisions at $\sqrt{s}$ = 2.76 TeV. Phys. Lett. B: 768: 203-217.

4. J. Adam et al. (ALICE Collaboration) (2017) W and Z boson production in p-Pb collisions at $\sqrt{s_{NN}}$ = 5.02 TeV. JHEP: 02: 077.
5. J. Adam et al. (ALICE Collaboration) (2017) Charged-particle multiplicities in proton-proton collisions at $\sqrt{s}$ = 0.9 to 8 TeV. Eur. Phys. J. C: 77: 33.
6. J. Adam et al. (ALICE Collaboration) (2016) Correlated event-by-event fluctuations of flow harmonics in Pb-Pb collisions at $\sqrt{s_{NN}}$ = 2.76 TeV. Phys. Rev. Lett.: 117: 182301.
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8. J. Adam et al. (ALICE Collaboration) (2016) Higher harmonic flow coefficients of identified hadrons in Pb-Pb collisions at $\sqrt{s_{NN}}$ = 2.76 TeV. JHEP: 1609: 164.
9. J. Adam et al. (ALICE Collaboration) (2016) Measurement of transverse energy at midrapidity in Pb-Pb collisions at $\sqrt{s_{NN}}$ = 2.76 TeV. Phys. Rev. C: 94: 034903.
10. J. Adam et al. (ALICE Collaboration) (2016) Elliptic flow of electrons from heavy-flavour hadron decays at mid-rapidity in Pb-Pb collisions at $\sqrt{s_{NN}}$ = 2.76 TeV. JHEP: 09: 028.
11. J. Adam et al. (ALICE Collaboration) (2016) Measurement of D-meson production versus multiplicity in p-Pb collisions at $\sqrt{s_{NN}}$ = 5.02 TeV. JHEP: 8: 1-44.
12. J. Adam et al. (ALICE Collaboration) (2016) Multiplicity dependence of charged pion, kaon, and (anti) proton production at large transverse momentum in p-Pb collisions at $\sqrt{s_{NN}}$ = 5.02 TeV. Phys. Lett. B: 760: 720.
13. J. Adam et al. (ALICE Collaboration) (2016) Pseudorapidity dependence of the anisotropic flow of charged particles in Pb-Pb collisions at $\sqrt{s_{NN}}$ = 2.76 TeV. Phys. Lett. B: 762: 376-388.
14. J. Adam et al. (ALICE Collaboration) (2016) Centrality dependence of ψ(2S) suppression in p-Pb collisions at $\sqrt{s_{NN}}$ = 5.02 TeV. JHEP: 06: 50.
15. J. Adam et al. (ALICE Collaboration) (2016) Centrality dependence of the charged-particle multiplicity density at mid-rapidity in Pb-Pb collisions at $\sqrt{s_{NN}}$ = 5.02 TeV. Phys. Rev. Lett.: 116: 222302.
16. J. Adam et al. (ALICE Collaboration) (2016) Measurement of an excess in the yield of J/ψ at very low pT in Pb-Pb collisions at $\sqrt{s_{NN}}$ = 2.76 TeV. Phys.Rev.Lett.: 116: 222301.
17. J. Adam et al. (ALICE Collaboration) (2016) Differential studies of inclusive J/ψ and ψ(2S) production at forward rapidity in Pb-Pb collisions at $\sqrt{s_{NN}}$ = 2.76 TeV. JHEP: 05: 179.
18. J. Adam et al. (ALICE Collaboration) (2016) Particle identification in ALICE: a Bayesian approach. Eur. Phys. J. Plus: 131: 168.

19. J. Adam et al. (ALICE Collaboration) (2016) Centrality dependence of charged jet production in p-Pb collisions at $\sqrt{s_{NN}}$ = 5.02 TeV. Eur. Phys. J. C: 76: 271.

20. J. Adam et al. (ALICE Collaboration) (2016) Multi-strange baryon production in p-Pb collisions at $\sqrt{s_{NN}}$ = 5.02. Phys. Lett. B: 758: 389-401.

21. J. Adam et al. (ALICE Collaboration) (2016) Production of K* (892)0 and φ(1020) in p-Pb collisions at $\sqrt{s_{NN}}$ = 5.02 TeV. Eur. Phys. J. C: 76: 245.

22. J. Adam et al. (ALICE Collaboration) (2016) Charge-dependent flow and the search for the Chiral Magnetic Wave in Pb-Pb collisions at $\sqrt{s_{NN}}$ = 2.76 TeV. Phys. Rev. C: 93 : 044903.

23. J. Adam et al. (ALICE Collaboration) (2016) Inclusive quarkonium production at forward rapidity in pp collisions at $\sqrt{s}$ = 8 TeV. Eur. Phys. J. C: 76: 184.

24. J. Adam et al. (ALICE Collaboration) (2016) Anisotropic flow of charged particles in Pb-Pb collisions at $\sqrt{s_{NN}}$ = 5.02 TeV. Phys. Rev. Lett.: 116: 132302.

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

25. T. Ablyazimov *et al.* (CBM Collaboration) (2017) Challenges in QCD matter physics --The scientific programme of the Compressed Baryonic Matter experiment at FAIR. Eur.Phys.J. A53: no.3, 60.

(with R.P. Adak, S. Biswas, S. Das, S. K. Ghosh, D. Nag, Prof. S. Raha, D. Ghosal (IIM Dhanbad), A. Mondal (University of Calcutta), T. K. Nayak, R. N. Patra (VECC, Kolkata), P.K. Sahu, S. Sahu and S. Swain (IOP, Bhubaneswar))

26. R. P. Adak et al. (2016) Long-term stability test of a triple GEM detector. JINST: 11: no.10, T10001

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

(1) Participated in the "International Conference on Matter under High Densities" held at Sikkim Manipal Institute of Technology, Rangpo, Sikkim, India during June 21 – 23, 2016; (2) Delivered an invited talk on "Jets in Heavy Ion: Experiment" in a discussion meeting on JETS@LHC organized by TIFR at International Centre for Theoretical Sciences Bengaluru during January 21 – 28, 2017; (3) Attended the CNT workshop on Quarkonia Production and Suppression in High Energy Heavy Ion Collisions held at Calcutta University, Kolkata during February 13 – 15, 2017; (4) Participated in the conference "Advanced Detectors for Nuclear, High Energy and Astroparticle Physics" held at Bose Institute, Kolkata during February 15 – 17, 2017 (5) Participated in the Workshop on Testing and Evaluation Results of CBM related ASIC developments held at Bose Institute Darjeeling, during February 19 – 21, 2017.

Seminars / Symposia organized at Bose Institute:

Member of organizing committee of a conference, "Advanced Detectors for Nuclear, High Energy and Astroparticle Physics", held at Bose Institute, Kolkata during February 15 – 17, 2017.

Dr. Probir Roy

INSA Senior Scientist

Scientific Reports

Complex scaling in neutrino mass matrix and consequent baryogenesis

The utilization of the residual symmetry approach, along with a complex extension of the real scaling ansatz for the neutrino Majorana mass matrix generated by a type –I seesaw, enables us to show that the leptonic Dirac CP-violation has to be maximal while atmospheric neutrino mixing need not be so. Further, each of the two Majorana phases has to be at one of its CP-conserving values. Normal mass ordering is found to be allowed in this scheme which has a host of predictions that will be tested in ongoing and future long baseline neutrino experiments and in searches for neutrinoless double beta decay.

We also investigate baryogenesis via leptogenesis in this model. A common source of the origin of nonzero θ_{13} and the CP-violating lepton asymmetry as well as assumed hierarchical masses for the righthanded heavy neutrinos facilitate our analysis. The leptonic CP asymmetry parameter, originating from the dacays of the lightest of the heavy neutrinos N_1 at a temperature $T \sim M_1$, is what matters here. The light leptonic and heavy neutrino abundances are evolved via Boltzmann equations down to the electroweak temperature to yield a baryonic asymmetry through sphaleronic transitions. For best-fit values of inputted neutrino mass and mixing parameters from experiments, successful baryogenesis is obtained in the mass regime 10^9 GeV $< M_1 < 10^{12}$ GeV and for a normal light neutrino ordering. However , the case of an inverted mass ordering of the light neutrinos cannot be totally excluded.

Publications :

1. R. Samanta, P. Roy and A.Ghosal, (2016) Complex Scaling in Neutrino Mass Matrix, *Acta Phys.Polon.* Supp. 9, 807.
2. R. Samanta, P.Roy and A.Ghosal (2016) Extended scaling and residual flavor symmetry in the neutrino Majorana mass matrix, *Eur. Phys. J.C* 76, no. 12, 662.
3. R. Samanta, M. Chakraborty, P. Roy and A.Ghosal (2017) Baryon asymmetry via leptogenesis in a neutrino mass model with complex scaling, *JCAP* 1703, no. 03, 025.

Dr. Swapan K Saha

Senior Professor

Scientific Reports

Search for higher excited states of ^{8}Be* to study the cosmological ^{7}Li problem: *In collaboration with Dr. Dhruba Gupta*

The nuclear reactions that destroy ^{7}Be deserve special attention in the study of the cosmological lithium problem. Accurate measurements are required before one can invoke solutions beyond nuclear physics, particularly the newly conjectured light electrically neutral particles X that may have substantial interactions with nucleons. We continued our preparation for the planned experiment at HIE-ISOLDE, CERN, Geneva, Switzerland, measuring the destruction of ^{7}Be through the resonance excitation of ^{7}Be(d,p)^{8}Be* (IS 554). We would use the scattering chamber having sets of strip detectors covering a large angular range, installed at one of the beamlines of the HIE-ISOLDE facility. Substantial work has been carried out in installing NPTool, a framework based on Geant4 and ROOT for simulation and analysis of nuclear physics experiments. The simulations using NPTool as well as DWBA calculations for the reaction ^{7}Be(d,p)^{8}Be* using the code FRESCO have been carried out at Bose Institute.

Breakup of ^{7}Be in presence of heavy targets: *In collaboration with Dr. Dhruba Gupta*

Breakup reactions play a prominent role in loosely bound nuclei. In order to study the cosmological lithium problem the ^{7}Li production channel also deserves attention. This in turn is related to the ^{7}Be production channel through the radiative capture reaction ^{3}He + ^{4}He $\rightarrow$ ^{7}Be + $\tilde{\gamma}$. This 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.

Study of n-p pairing through two-nucleon transfer reactions: *In collaboration with Dr. Dhruba Gupta*

Analysis of the data for the n-p pairing experiment (e644) at the rare isotope facility GANIL, Caen, France was continued. The aim of this experiment is to study two nucleon n-p transfer reactions on two nuclei, a mid-shell nucleus ^{48}Cr, a candidate for n-p pairing correlations, and the doubly magic nucleus ^{56}Ni which will not show any pairing effects. On both these nuclei we measured (p,^{3}He) and (d,α) reactions in order to investigate the competition between T=1 and T=0 pairing and probe n-p pairing. We are carrying out a part of the data analysis at Bose Institute in the NPTool framework in collaboration with IPN, Orsay, France. Detailed analysis have been carried out to calibrate the double sided strip and CsI detectors of MUST2 in e644 using α-source. A preliminary analysis shows that n-p pairing in ^{56}Ni is mainly of isovector type.

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

Experimental advancements in the field of nuclear physics allow us nowadays to study exotic unstable and even unbound nuclei. Theoretically, it is very difficult to tackle the unbound states by conventional methods. Earlier, we used a very effective technique to detect low-lying broad resonances of weakly bound nuclei. Its success encouraged us to apply it effectively for unbound nuclei like ^{15}Be. We used the theoretical procedure of supersymmetric quantum mechanics (SQM) to study their resonance states. We could reproduce the unbound state energies without any modification of our constructed density dependent M3Y (DDM3Y) microscopic potential. Our procedure confirmed the existence of $5/2^+$ state and also reproduced the experimentally predicted unbound resonance energy of 1.8 MeV. The generated potential, depending on a suitably chosen parameter, is strictly isospectral with the original DDM3Y potential although the two have widely different shapes. This fact could also be utilized to calculate other observables of ^{15}Be.

Publications :

1. Dutta S K, Gupta D, Saha Swapan K (2016) Study of Unbound States of ^{15}Be using Supersymmetric Quantum Mechanics, *arXiv:1703.09448v1 [nucl-th]*

Symposium publication :

1. Dutta S K, Gupta D, Saha Swapan K (2016) Study of unbound states of ^{15}Be using supersymmetric quantum mechanics, *Proceedings of the DAE-BRNS Symposium on Nuclear Physics* 61, 80
2. Sinha M, Gupta D, Saha Swapan K (2016) Resonance excitation in ^{7}Be + d reaction to study the cosmological lithium problem, *Proceedings of the DAE-BRNS Symposium on Nuclear Physics* 61, 886

Grants-in-Aid Schemes :

Title of Scheme	Schemes funded by
(*With Dr. Dhruba Gupta as PI*) Astrophysical S-factor from nuclear reactions with a rare isotope beam of ^{7}Be"	ISRO

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

Participated and presented a poster titled "Transfer reactions with ^{7}Be to study the cosmological lithium problem" at the ISOLDE Workshop and Users Meeting 2016, CERN, Geneva, Switzerland, December 7 – 9, 2016.

Group Member :

Dr. M. Sinha (RA) presented a poster titled "Resonance excitation in ^{7}Be + d reaction to study the cosmological lithium problem" at the 61st DAE-BRNS Symposium on Nuclear Physics at SINP, Kolkata, December 5 – 9, 2016 and was awarded as one of the best poster presentations.

Dr. Rajarshi Ray

Associate Professor

Scientific Reports

Physics of strongly interacting matter: *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 an estimation 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.

In collaboration with Abhijit Bhattacharyya (CU), Sanjay K. Ghosh, Kinkar Saha and Sudipa Upadhaya

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

In collaboration with Abhijit Bhattacharyya (CU), Sanjay K. Ghosh and, Subhasis Samanta

We performed a study of the effects of magnetic fields on fluctuations and correlations in hadron resonance gas model. We found significant changes in the fluctuations of net baryon number, electric charge and strangeness. This is also reflected in various fluctuation ratios along the freezeout curve.

Publications :

1. 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.
2. Bhattacharyya A, Ghosh S K, Ray R, Saha K and Upadhaya S (2016) Polyakov--Nambu--Jona-Lasinio model in finite volumes. *Europhysics Letters* 116:52001.
3. Bhattacharyya A, Ghosh S K, Ray R and Samanta S (2016) Exploring effects of magnetic field on the Hadron Resonance Gas. *Europhysics Letters* 115:62003.

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

(I) Presented an invited lecture on *Fluctuations in the PNJL model* in the International Conference on Matter under High Densities, held at Sikkim Manipal Institute of Technology, Sikkim, India, in June 2016. (ii) Presented an invited lecture on *Progress in model studies of strong interactions* in the One day seminar on properties of nuclear fluid held at Variable Energy Cyclotron Center, Kolkata, India, in December 2016.

Dr. Soumen Roy

Associate Professor

Scientific Reports

Walks on correlated, connected fitness landscapes

In light of recent experiments, the idea of evolutionary hypercubes can be extended to sequence spaces of complex structure, where the values of fitness may be correlated or uncorrelated. The primary focus in the past has been on strictly adaptive walks like random adaptive walks, natural adaptive walks and gradient adaptive walks, which by definition are designed to lead the population to a fitter or even the fittest neighbor.

We propose a new class of walks on these spaces and explore their importance.

Publications :

1. Banerjee SJ, Grewal RK, Sinha S and Roy S (2016) The network route to biological complexity" in BIOMAT 2015 - Proceedings of the 15'th International Symposium on Mathematical and Computational Biology - IIT Roorkee, *Publisher: World Scientific. Editor: Mondaini*.
2. Grewal RK, Sinha S and Roy S (2016) “Systems biology in plant cells and their organelles” in "Plant cells and their organelles” *Publisher: John Wiley & Sons Ltd. Editors: Dashek and Miglani.*

3. Samaddar S, Grewal RK, Sinha S, Ghosh S, Roy S and Das Gupta SK (2016) Dynamics of Mycobacteriophage-Mycobacterial host interaction - evidence for secondary mechanisms for host lethality, *Applied and Environmental Microbiology* [ASM] 82 124-133.
   [Also selected as article of significant interest by Editors for AEM Spotlight]

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

Delivered talks at i) Refresher course, Academic staff college, University of Calcutta Feb 13, 2017 ii) National symposium on computational systems biology and bioinformatics during November 12 - 14, 2016 iii) Theoretical Physics Seminar Circuit, Department of Physics, Banaras Hindu University October 28'th, 2016 iv) Physics Colloquium, Department of Physics, Presidency University, Kolkata August 17, 2016 v) "Statistical physics methods in biology and computer science" (satellite meeting of STATPHYS 2 vi) at Ecole Normale Superieure de Paris on July 16, 2016 vii) "Complex Networks: from theory to interdisciplinary application" (Satellite meeting of STATPHYS 26) at Palais du Pharo, Marseilles on July 13, 2016.

Awards / Honours received :

Appointed as a Regular Associate of the International Centre for Theoretical Physics of UNESCO at Trieste, Italy.

Dr. Achintya Singha

Associate Professor

Scientific Reports

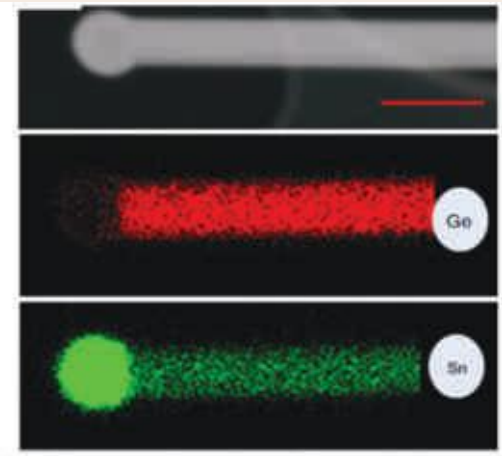
Tin doped germanium: A direct bandgap $Ge_{1-x}Sn_x$ nanowires: *in collaboration with Dr. Subhajit Biswas and Prof. Justin D. Holmes of University College Cork, Cork , Ireland and Dr. Dipanwita Majumdar.*

A non-equilibrium group IV nanoscale alloy has been developed to achieve new functionalities, such as the formation a direct bandgap in semiconductors where indirect bandgap elemental semiconductors are conventional. An uniform diameter, direct bandgap Ge1-xSnx alloy nanowires, has been fabricated where tin has been incorporated up to 9.2 at.%, which is far in excess of the equilibrium solubility of tin in bulk germanium. This was done through a conventional catalytic bottom-up growth paradigm where noble metal and metal alloy catalysts have been used. These metal alloy catalysts permit a greater inclusion of tin in germanium nanowires in comparison to conventional gold catalysts, when used during vapor- liquid-solid growth.

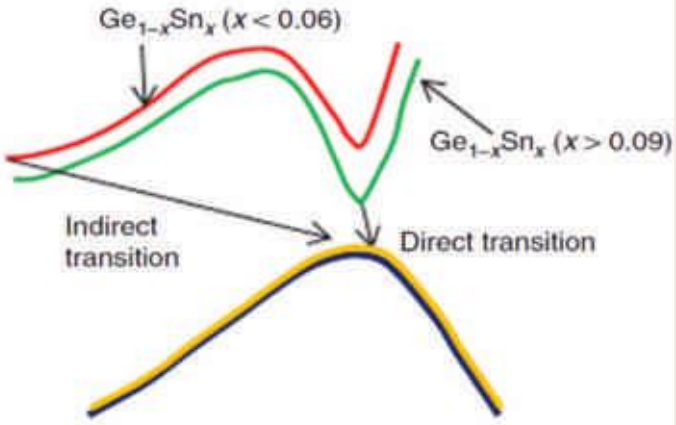
EDX mapping and schematic representation of band structure of Sn doped Ge nanowire

An annealing step close to the tin-germanium eutectic temperature (230°C) during cool-down was introduced which further facilitated the excessive dissolution of tin in the nanowires. Tin was

distributed throughout the germanium nanowire lattice, and with no metallic tin segregation precipitation at the surface or within the bulk of the nanowires was observed through EDX and Raman studies. The evidence of the formation of direct bandgap was proved by the temperature dependent photoluminescence measurements. The non-equilibrium incorporation of tin into the germanium nanowires can be understood in terms of a kinetic trapping model. This work addresses towards the ongoing demand for a nanoscale material for group IV photonics. [Nat. Commun., 7, 11405 (1-12) (2016)]



EDX mapping for Ge and Sn in a $Ge_{1-x}Sn_x$ nanowire



Study of opto-chemical doping in Ag nanoparticle-decorated monolayer graphene by Raman spectroscopy: *in collaboration with Mr. Rishi Maiti and Prof. S. K. Ray of IIT Kharagpur and Dr. Dipanwita Majumdar*

The novel opto-chemical doping effect in Ag nanoparticle-decorated monolayer graphene grown by chemical vapor deposition has been investigated using Raman spectroscopy for the first time. Metal nanoparticle-induced chemical effects and laser power-induced substrate effects alter the doping nature of graphene from p- to n-type. This study will be useful for tuning graphene plasmons on the widely used Si/SiO_2 substrates for various photonic device applications. [Nanotechnology 28 (2017) 075707].

Publications :

1. Ansari Z, Sarkar K, Saha A, Singha A and Sen K (2016) Enhanced anion sensing by γ-irradiated polyphenol capped iron oxide nanoparticles. *J Radioanal Nucl Chem.*, 308: 517–525 Impact Factor: 0.983
2. Biswas S, Dohertyy J, Saladukha D, Ramasse Q, Majumdar D, Upmanyu M, Singha A, Ochalski T, Morris M A and Holmes J D (2016) Non-equilibrium induction of tin in germanium: towards direct bandgap $Ge_{1-x}Sn_x$ nanowires. *Nature communication.*, 7: 11405 (1-12). Impact Factor: 12.124.

3. Konar A, Sarkar T, Chakraborty I, Sukul N C, Majumdar D, Singha A and Sukul A (2016) Raman spectroscopy reveals variation in free OH groups and hydrogen bond strength in ultrahigh dilutions. International. *Journal of High Dilution Research.,* 15: 2-9.

4. Maiti R, Haldar S, Majumdar D, Singha A and Ray S K (2017) Hybrid opto-chemical doping in Ag nanoparticle-decorated monolayer graphene grown by chemical vapor deposition probed by Raman spectroscopy. *Nanotechnology,* 28, 075707 (8pp). Impact Factor: 3.44

5. Samanta S, Saini D, Singha A, Das K, Bandaru P R, Rao A M and Raychaudhuri A K (2016) Photoresponse of a single Y-junction carbon nanotube. *ACS Appl. Mater. Interfaces.,* 8: 19024-19030. Impact Factor: 7.504

Students Awarded Ph.D. :

Name of the Student University/Year	Title of Thesis
Dipanwita Majumdar (C.U., 2016)	Study of Nanomaterials and Ultra Sensitive Molecular Detection using Raman Spectroscopy

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

(I) Delivered invited talk at one day state level seminar on Nanomaterials: syanthesis and applications organized by Ramananda College, Bishnupur, Bankura (ii) participated as an expert in a panel discussion on Optical Methods in Science in a UGC-sponsored two days National Conference on the central Role of light in science and the Importance of Optical Technologies during 15 – 16 December organized by St. Paul's Cathedral Mission college, Kolkata in collaboration with Calcutta Institute of Theoretical physics, Kolkata.

Group Members :

Mr. Shib Shankar Singha (Physics): Attended and presented a poster in One-Day Symposium on Nanotechnology: From Materials to Medicines and Their Social Impact on March 25, 2017, organized by Centre for Interdisciplinary Research and Education at Birla Industrial and Technological Museum, Kolkata.

Mr. Tara Shankar Bhattacharya (Physics): Attended and presented a poster at (i) International Conference on Advances in Biological Systems and Material Science in NanoWorld (ABSMSNW-2017) during February 19 – 22, 2017, organized by Department of Physics, Indian Institute of Technology (BHU), Varanasi, (ii) One-Day Symposium on Nanotechnology: From Materials to Medicines and Their Social Impact on March 25, 2017, organized by Centre for Interdisciplinary Research and Education at Birla Industrial and Technological Museum, Kolkata.

Mr. Sreyan Raha (Physics): Attended and presented a poster at International Conference on Advances in Biological Systems and Material Science in NanoWorld (ABSMSNW-2017) during 19th – 22nd February 2017, organized by Department of Physics, Indian Institute of Technology (BHU), Varanasi,

Awards / Honors received :

Group Members :

Mr. Shib Shankar Singha received 2nd prize in poster presentation in One-Day Symposium on Nanotechnology: From Materials to Medicines and Their Social Impact on March 25, 2017, organized by Centre for Interdisciplinary Research and Education at Birla Industrial and Technological Museum, Kolkata.

Dr. T. P. Sinha

Senior Professor

Scientific Reports

Electrical transport mechanism of perovskite oxides

The structure of synthesized complex perovskite oxides (Sr_2SmNbO_6, Ba_2CeSbO_6, Pr_2NiZrO_6, A_2HoSbO_6 (A = Ba, Sr, Ca) etc.) have been established by Rietveld refinement technique. The frequency dependent dielectric relaxation (a conduction process) of these *synthesized* perovskite oxides *has been investigated by impedance spectroscopy at different temperatures.* The activation energy of the system is obtained and the transport mechanism for the conduction process has been proposed.

Antiferromagnetism in perovskite oxides

Magnetic properties of some rare-earth and transition metal based perovskite oxides have been investigated by measuring the magnetic susceptibility in the zero-field cooled and field cooled conditions. Spin polarized calculations have been performed using density functional theory. The spin-orbit coupling and the on-site Coulomb potential are considered in the calculation to analyse the observed magnetic moments.

Density of States and Electronic structure of perovskite oxides

The density functional theory under generalized gradient approximation has been employed to understand the various interactions leading to the optical, vibrational and magnetic properties in the perovskite oxides. The calculated density of states is compared with the experimental density of states obtained by x-ray photoemission spectroscopy. The interband contribution to the optical

properties of these perovskite oxides has been analyzed. The zone centre phonon mode calculations have been performed which is used to explain the observed vibrational modes by Raman and infrared spectroscopy of the materials.

Publications :

1. Chanda S, Saha S, Dutta A, Krishna Murthy J, Venimadhav A, Shannigrahi S and Sinha T P (2016) Magnetic ordering and conduction mechanism of different electroactive regions in La_2NiMnO_6, *Journal of Applied Physics*, vol. 120, pp. 134102(1-10).
2. Das I, Chanda S, Saha S, Dutta A, Banerjee S, Bandyopadhyaya S and Sinha T P (2016) Electronic structure and transport properties of antiferromagnetic double perovskite Y_2AlCrO_6, *Royal Society of Chemistry Advances*, vol. 6, pp. 80415-80423.
3. Dutta A, Mukhopadhyay P K, Sinha T P, Shannigrahi S, Himanshu A K, Sen P and Bandyopadhyay S K (2016) *Sr_2SmNbO_6 perovskite: Synthesis, Characterization and density funtional theory calculations, Materials Chemistry and Physics*, vol. 179, pp. 55-64
4. Dutta A, Mukhopadhyay P K, Sinha T P, Das D and Shannigrahi S (2016) Structural and magnetic properties of double perovskite oxide Ba_2CeSbO_6, *Solid State Sciences*, vol. 58, pp. 64-69
5. Halder S, Dutta A and Sinha T P (2017) Dielectric relaxation and electrical conduction mechanism in A_2HoSbO_6 (A = Ba, Sr, Ca) double perovskite ceramics: An impedance spectroscopic analysis, *Journal of Physics and Chemistry of Solids*, vol. 102, pp. 79-89
6. Hoque M M, Barua A, Dutta A, Dey S K, Sinha T P and Kumar S (2017) Study on the structural, spectroscopic, and dielectric properties of 1:2 ordered $Ca_3(BTa_2)O_9$ (B = Mg and Zn), *Ionics*, vol. 23, pp. 473-483
7. Mahato D K, Saha S and Sinha T P (2016) Impedance, scaling behavior and conduction mechanism in double perovskite Pr_2CuZrO_6, *Journal of Materials Science: Materials in Electronics*, vol. 27, pp. 3845-3853.
8. Mahato D K, Rudra M and Sinha T P (2016) Structural and electrical features of rare earth based double perovskite oxide: Pr_2NiZrO_6, *Journal of Alloys and Compounds, vol. 689,* pp. 617-624.
9. Mahato D K and Sinha T P (2017) Observation of semiconductor to metallic transition and polaron hopping in double perovskite Pr_2CoTiO_6 ceramics, *Physica B*, vol. 512, pp. 85-90.
10. Mahato D K and Sinha T P (2017) Dielectric, impedance and conduction behaviour of double perovskite Pr_2CuTiO_6 ceramics, *Journal of Electronic Materials*, vol. 46, pp. 107-115.
11. Mondal T, Das S, Badapanda T, Sinha T P and Sarun P M (2017) Effect of Ca^{2+} substitution on impedance and electrical conduction mechanism of $Ba_{1-x}Ca_xZr_{0.1}Ti_{0.9}O_3$ ($0.00 \leq x \leq 0.20$) ceramics, *Physica B,* vol. 508, pp. 124-135.

12. Rai D P, Sandeep, Shankar A, Sakhya A P, Sinha T P, Khenata R, Ghimire M P and Thapa R K (2016) Electronic and magnetic properties of X_2YZ and XYZ Heusler compounds: A comparative study of density functional theory with different exchange-correlation potentials, *Materials Research Express*, vol. 3, pp. 075022.

13. Rai D P, Sandeep, Shankar A, Sakhya A P, Sinha T P, Merabet B, Saad M M, Khenata R, Boochani A, Solaymani S and Thapa R K (2017) Electronic and optical properties of cubic $SrHfO_3$ at different pressures: a first principles study, *Materials Chemistry and Physics*, vol. 186, pp. 620-626.

14. Ray R, Himanshu A K, Sen P, Kumar U, Richter M and Sinha T P (2017) Effects of octahedral tilting on the electronic structure and optical properties of d^0double perovskites A_2ScSbO_6 (A = Sr, Ca), *Journal of Alloys and Compounds*, vol. 705, pp. 497-506.

15. Saha S, Chanda S, Dutta A and Sinha T P (2016) *Dielectric relaxation of $PrFeO_3$ nanoparticles*, *Solid State Sciences*, vol. 58, pp. 55-63.

16. Saha S, Chanda S, Dutta A, Das D and Sinha T P (2016) *Dielectric dispersion and antiferromagnetism in $BiTb_xFe_{1-x}O_3$ (x = 1.0, 0.75)*, *Journal of Magnetism and Magnetic Materials*, vol. 398, pp. 289-297.

17. Sakhya A P, Rai D P, Sandeep, Dutta A, Thapa R K and Sinha T P (2016) Electronic, optical and thermoelectric properties of $PrMO_3$ (M = Al, Ga, In) from first-principles calculations, *Royal Society of Chemistry Advances*, vol. 6, pp. 59988-59997.

18. Sandeep, Rai D P, Shankar A, Ghimire M P, Sakhya A P, Sinha T P, Khenata R, Omram S B and Thapa R K (2016) Band-gap engineering of $La_{1-x}Nd_xAlO_3$ (x = 0, 0.25, 0.5, 0.75, 1) perovskite using density functional theory: a modified Becke Johnson Potential study, *Chinese Physics B*, vol. 25, pp. 067100.

Conference/Symposia publications :

1. Das S, Banerjee S and Sinha T P (2016) Magnetic study of Fe-doped CdSe nanomaterials, *AIP Conference Proceedings*, vol. 1728, pp. 020105.

2. Ghosh B, Halder S, Das S and Sinha T P (2016) Understanding the photoluminescence characteristics of Eu3+-doped double-perovskite by electronic structure calculation, *AIP Conference Proceedings*, vol. 1731, pp. 090018.

3. Saha S, Dutta A, Mukhopadhyay P K and Sinha T P (2016) Dielectric relaxation and charge transport process in $PrCrO_3$ nano-ceramic, *Nanosystems: Physics, Chemistry, Matematics*, vol. 7, pp. 613-617.

Participation in Conferences/ Symposia/ Workshops and Invited talks delivered at various organizations :

(I) Delivered an invited talk on "Dilute magnetic semiconducting behaviour of Fe-doped CdSe nanoparticles" in the International Conference on Nanotechnology for Better Living at National Institute of Technology, Srinagar during 25 – 29 May 2016 (ii) delivered a key-note address on "Frequency dependent dielectric constant of perovskite oxides" in the National symposium on Condensed Matter CMDAYS-2016 at Mizoram Central University, Aizawl during August 29 – 31, 2016 (iii) delivered an invited talk on "Electrical and optical dielectric constant of perovskite oxides" in the National Conference on Nanoscience, Nanotechnology and Advanced Materials (NCNNAM-2016) at Birla Institute of Technology Mesra, Ranchi during September 26 – 27, 2016 (iv) delivered an invited talk on "Electrical and optical dielectric constants of perovskite oxides" in the International Conference on Multifunctional Materials for Device Application at National Institute of Technology, Patna during October 26 – 28, 2016 (v) delivered an invited talk on "Dielectric Relaxation of perovskite oxides" in the International Conference on Technologically Advanced Materials and Asian Meeting on Ferroelectricity at University of Delhi, New Delhi during November 7 – 11, 2016 (vi) delivered an invited talk on "Electrical and optical dielectric constants of perovskite oxides" in the International Conference on Advanced Material (SCICON 16) at Amrita University, Coimbatore during December 19 – 21, 2016.

Group Members :

Saswata Halder presented a paper on (i) 'Exploring the electronic and optical properties of double perovskite Ba_2RESbO_6 (RE = Ho, Er) from first principles calculation' at the International Conference on Technologically Advanced Materials (ICTAM) and Asian Meeting on Ferroelectricity (AMF) held at University of Delhi, New Delhi during November 7 – 11, 2016; (ii) 'Understanding the X-ray photoelectron spectroscopy and Photophysical properties of double perovskite A_2SmTaO_6 (A = Ba, Sr, Ca) from First Principles Density Functional Theory Calculations' at IUMRS-ICYRAM held at Indian Institute of Science, Bangalore during December 11 – 15, 2016.

Md. Sariful Sheikh presented a paper on (i) 'Optical and electrical properties of ZnTe nanostructures' at the International Conference on Nanotechnology for Better Living held in NIT Srinagar during May 25 – 29, 2016; (ii) 'Schottky diode like behaviour in FTO/Dy_2NiMnO_6/Ag device' at the International Conference on Functional Nano-Materials (ICFNM 2016) held in IIEST, Shibpur, West Bengal during September 28 – 29, 2016; (iii) 'Investigation of light induced charge transport properties in Dy_2NiMnO_6 perovskite based Schottky diode' at the International Conference on Technologically Advanced Materials and Asian Meeting on Ferroelectricity (ICTAM-AMF 10) held in Delhi University during November 7 – 11, 2016; (iv) 'Photo induced electronic property in La_2NiMnO_6 thin film' at the International Symposium on Semiconductor Materials and Devices (ISSMD 4) held in Jadavpur University, Kolkata during March 8 – 10, 2017.

Ritwik Maity presented a paper on 'Ac Conductivity & Raman Spectroscopic Studies of $PrMnO_3$ Nanostructure' at ICFNM 2016 held in IIEST, Shibpur, West Bengal during September 28 – 29, 2016.

Moumin Rudra presented a paper on 'Structural and dielectric characterization of Sm_2MgMnO_6' at ISSMD 4 held in Jadavpur University, Kolkata during March 8 – 10, 2017.

Anup Pradhan Sakhya presented a paper on (i) 'Electronic, optical and thermoelectric properties of $PrMO_3$ (M = Al, Ga, In) from first-principles calculations' at CMDAYS 2016, held in Mizoram University, Mizoram during August 29 – 31, 2016; (ii) 'Theoretical and experimental investigation of the electronic structure of A_2LiRuO_6 (A = Pr,Nd,Sm) double perovskite oxides' at the International Symposium on Semiconductor Materials and Devices (ISSMD 4) held in Jadavpur University, Kolkata during March 8 – 10, 2017.

OUTREACH AND MAN POWER DEVELOPMENT

Dissemination of knowledge has been an integral part of the charter of Bose Institute as proclaimed by J. C. Bose in his foundation speech in 1917. In recent years many outreach programmes has been undertaken to acquaint the school children's with the wonders of science and encourage them to pursue a career in science. Hands-on training of students from North-East states has become an annual event of Bose Institute for last nine years. Training programmes for the students of school students of Darjeeling is held regularly at the Darjeeling campus of Bose Institute. The faculties working at Darjeeling campus interact with the school students in regular intervals. Moreover, school students participating in the children's science congress interact with our faculties for their project work. Bose Institute also collaborates with other organizations for organizing science camps for school students in and around Kolkata. Hands-on training camps has also been organized for the school teachers of North-Eastern states as well as Darjeeling to help them in integrating the experiment based teaching with their regular class room teaching.

In order to extend the benefit of the advancement of our knowledge to rural sector Bose Institute is running a rural biotechnology programme at Falta Experimental Farm. Under this programme the people from rural sector/scheduled caste/scheduled tribe people are given training on various income generation schemes and for scheduled caste and scheduled tribe people Bose Institute helped them to implement the scheme in their own land. In the current year under the DST-SEED project 80 scheduled caste people were given training through 4 training schedule on mushroom cultivation, vermicompost production, apiculture and sericulture and out of the 80 trainees 40 were provided with facilities for mushroom cultivation, vermicompost production and apiculture. Under "Scheduled Tribe-Specific Rural Biotechnology Programme" Bose Institute has started implementing various income generation schemes directly through departmental machinery and through some NGOs in five districts of West Bengal.

Bose Institute also organizes a Winter School in Astroparticle Physics (WAPP) every year in collaboration with Cosmic Ray Laboratory (CRL), TIFR as a part of man power development programme at Ooty and Darjeeling in alternate years. Under this programme M.Sc students as well fresh research scholar students are give hand-on training on the different aspects of Astroparticle Physics. Bose Institute organized the WAPP 2015 during December 17-29, 2015 in Darjeeling.

A major step for the development of trained man power was taken in 2006 when Bose Institute started M.Sc courses in Physical and biological sciences. Physical Science course was initiated in collaboration with St. Xaviers College, Kolkata, Calcutta University being the degree granting Institute. Biological Science course was started in collaboration with Calcutta University. The success of both of these courses was encouraging. So keeping in view the Institute's objective of creating man power for research, new plans were formulated to initiate M.Sc-Ph.D integrated

course and subsequently M.Sc-Ph.D integrated course in life sciences was started in 2011 and Physical Science course was initiated in 2012.

Hand-on training programmes:

(a) NESST-BASE 2015: April 25 – May 7, 2016.

The Tenth North-East Students' Summer Training on BAsic SciEnces (NESST-BASE) was held at Darjeeling during April 25 – May 7, 2016. NESST-BASE2016 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. As a part of centenary Celebration, for a bigger participation, this year popular lecture programme was held in Gorkha Rangmanch Bhawan of Darjeeling on April 30, 2016. Around 500 School students from Darjeeling district attended this popular lecture programme. Three lectures on human genome, diffusion processes and climate change were delivered by experts of these fields and was well received by the students.

(b) Rural Biotechnology programmes:

All sorts of knowledge are there in the literature for improvement of rural economy but in reality very little is translated in the rural India. So instead of conducting training within the four walls of the Institute we planned to conduct onsite training directly through the implementation of the programme. In five districts of West Bengal namely Purulia, Bankura, Birbhum, West Medinipore and South 24-Parganas we selected some villages, made some stake in some villages, our staff stayed with them throughout the year, organized tribal people through group meeting, aware them about different income generation programmes, implemented each and every programme with the villagers in their own land with full or partial financial support and guide them up to marketing. Our training programme goes on throughout the year along with their daily life and we will be along with them as long as the “Scheduled Tribe-Specific Rural Biotechnology Programme” will exist at Bose Institute. The tribal people who are generally known as lazy are working hard for their own development. Bose Institute is proud to be associated with the distressed scheduled tribe people of the backward regions of our state.

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 2016, around 200 students applied from all over India. 90 students were shortlisted for written test and then 40 students were called for interview based on their performance in the written test. Finally 6 students were selected and all of them joined the M.Sc course. The first semester classes for this batch commenced in the first week of August.

(b) Biological Sciences

A total of 305 valid applications were received from which 211 candidates were shortlisted for the Written Exam, based on the criteria that the average marks in Science subjects (in Class X and XII) be more than equal to 78.5%. Based on the written test, 42 candidates were interviewed of which 12 candidates were finally selected. Classes started from August 2015.

NESST-BASE 2016:April 25 – May 7, 2016

The North-East Students' Summer Training on BAsicSciEnces (NESST-BASE) completed its 10 successful years in 2016. It was held at Darjeeling during April 25 – May 7, 2016. NESST-BASE2016 has been a part of Centenary Celebration of Bose Institute. A total of 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.

As a part of centenary Celebration, for a bigger participation, this year popular lecture programme was held in Gorkha Rangmanch Bhawan of Darjeeling on April 30, 2016. Around 500 School students from Darjeeling district attended this popular lecture programme. Three lectures on human genome, diffusion processes and climate change were delivered by experts of these fields and were well received by the students.

Prof. Sushanta Duttagupta, Ex-Vice Chancellor, Visva Bharati University on **"The exciting and all-prevading world of difusion"**

Prof Chandra Venkatraman, Indian Institute of Technology, Mumbay on **"Climate change and poor air quality in India: What can we do to combat it?"**

Prof. Partha P. Majumder, National Institute of Biomedical Genomics, Kalyani & Indian Statistical Institute, Kolkata **on "GENOMICS: What's All This Excitement?"**

SERVICE DEPARTMENTS

Acharya J.C. Bose Biotechnology Innovation Centre

(Madhyamgram Experimental Farm)

Madhyamgram Experimental Farm (MEF) serves the research centering on crop improvement and exploration of hitherto unexplored plant genetic resource. MEF encompasses impeccably maintained agricultural field, advanced biotechnology laboratory and several greenhouses.

In the last year (April 2016 – March 2017) Prof A N Lahiri Majumder, Prof Sampa Das, Prof D N Sengupta, Dr. S Chaudhuri and Dr. Anupama Ghosh have used the experimental plots of field for rice cultivation in the kharif season in connection to their respective research programmes.

Apart from rice, oilseed crops like sesame and mustard are grown in different seasons. Prof S Sikdar and Dr Gaurab Gangopadhyay are experimenting on improvement of sesame, while Prof Sampa Das, Prof D Basu and Prof S Sikdar are experimenting on biotic stress response of different varieties of mustard.


Prof Sampa Das has also availed the field facility for growing pigeon pea and chick pea (along with Prof D Basu) in ravi season in connection to different research programmes. Prof M Dasgupta (Department of Biochemistry, CU) and Dr S Chaudhuri grew ground nut successfully while Dr A Ghosh have used the field facility for the cultivation of maize.


For successful implementation of different molecular biological experiments with tomato and tobacco Dr P Kundu, Dr S Chaudhuri and Dr A Bhuina have used both field and transgenic green house facilities. Prof Sampa Das also availed green house facility for research on pigeon pea. In connection to different funded projects Prof A N Lahiri Majumder and Prof D N Sengupta have used transgenic green house facilities for rice. Prof Sampa Das, Prof D Basu and Prof S Sikdar have availed the facility of green houses for mustard. Dr S Chaudhuri has successfully grown Arabidopsis in MRF green house.


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.

MEF organized a Hands-on-Training programme on "Basic and Applied Biological Sciences for the High School Students from 22nd to 24th November 2016 as a part of the Centenary Celebration of Bose Institute. Twenty students of Class XI-XII standard along with their teachers from five schools in the vicinity of MEF attended this programme. They performed experiments on Plant Physiology, Plant Biotechnology and learnt techniques to use of animals in drug development/translational medical research. The students also visited the Rural Biotechnology Programme implemented at Falta Experimental Farm of Bose Institute.

Central Instruments Facility

The Central Instruments facility (which includes the DST/ IRHPA sponsored National center for proteomics and genomics) is an independent unit within the institute which houses a large number of sophisticated instruments required for advanced research in biological and chemical sciences. The facility is run by a group of highly trained technicians who not only look after the instrument but also advise research students about how to use them effectively.

The equipments that are currently available are as follows:

A) DNA sequencer

B) Confocal Microscope

C) HPLC

D) CD Spectrometer

E) Cell sorters

F) Documentation systems

G) NMR (700 MHz)

H) GC MS

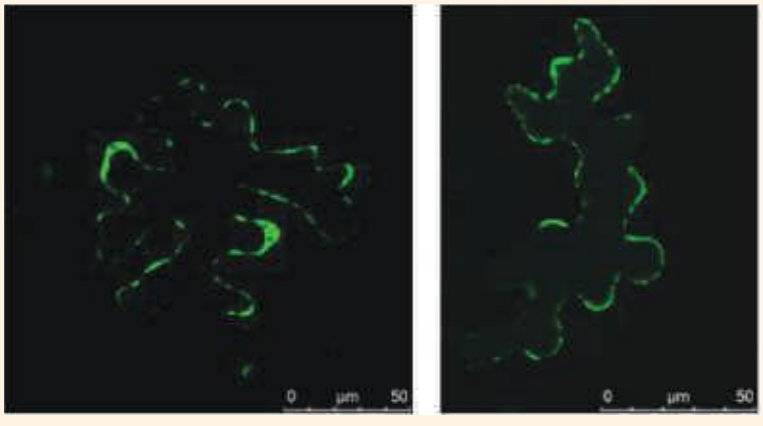
I) Fluorescence spectrophotometer

J) RT PCR.

K) Atomic Absorption Spectrophotometer

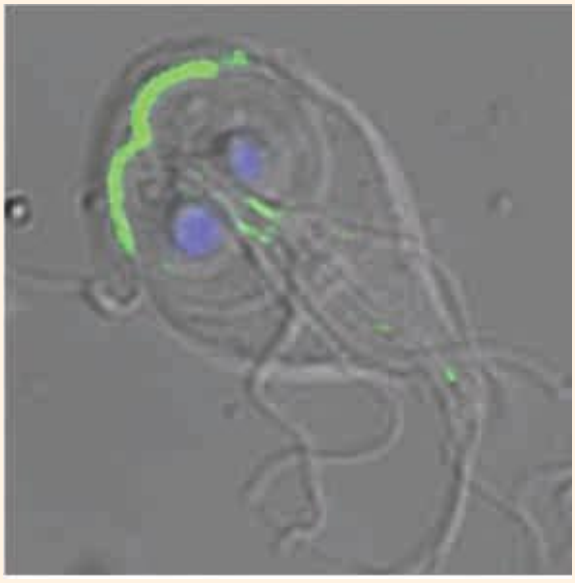
L) MALDI TOF-TOF

The demand for CIF equipments is increasing every year. The DNA sequencer(3500XL) in particular has been used extensively. In the last financial year as many as 7000 samples were analyzed. The HPLC system has been used extensively particularly for the isolation of bioactive compounds from plant materials. Apart from internal users, the HPLC facility at the CIF has been used by scientists from different universities and institutes who are engaged in traditional medicine research.. As usual the confocal microscope and FACS are in heavy demand. The CIF facilities are being upgraded and recently a new MALDI-TOF-TOF has



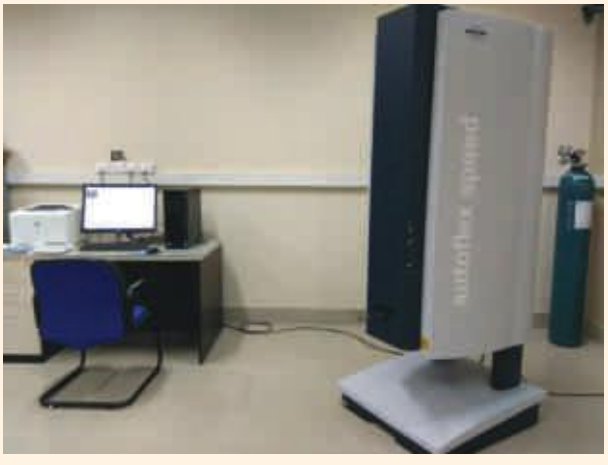
localization pattern of GFP tagged plant immune receptor in *Nicotiana benthamiana* leaves

been procured, which has been located at the Unified Campus building at sector V, Salt lake. 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.



Giardia lamblia Protein SNAP: A component of the vesicular trafficking machinery associates with the intracellular segment of the flagella of the binucleate human pathogenic protist of Giardia lamblia

Students from Shivaji University, Kolhapur, Maharashtra familiarizing themselves with CIF equipment



Newly acquired MALDI TOF-TOF(AUTOFLEX SPEED TOF/TOF) installed at unified campus

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 (2016-17)

- Various phenomenological models presented over the years have hinted at thepossible 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 anysuch array can begin, a detailed study of the radiation background is essential. Also, aproper 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.
- A study has been carried out to study the effect of physical characteristic of rain on aerosol scavenging. Chemical composition of aerosol before rain event during rain event and after rain event indicates that the rain intensity played a major role in aerosol scavenging in fine mode and coarse mode aerosol. High scavenging of coarser mode aerosol was observed in low rain-rate (< 5.0 mm hr^{-1}). On the other hand, fine mode aerosol scavenged well by higher rain-rate (> 5.0 mm hr^{-1}). Higher concentration of coarse mode sea-salt particles during rain indicates presence of low cloud in the sampling area. Scavenging and regeneration of fine and coarse mode aerosol were found to be different for different rain rate.
- In a separate study it was found that major VOCs and carbonyl compounds like benzene, toluene, ethylbenzene, xylene, acetone, formaldehyde and acetaldehyde over Darjeeling are comparable and sometimes higher than some of the metro cities in India and other parts of the world. Both VOCs and carbonyl compounds showed distinct seasonal variation with the maximum concentrations during postmonsoon followed by monsoon and winter ~ premonsoon. Surface reaching solar radiation seems to play a major role in photochemical production/ degradation of VOCs and carbonyl compounds over Darjeeling.
- In a study to understand CN and CCN activation, it was observed that submicron aerosols became more hygroscopic during their transport by external mixing during pre-monsoon, which in turn got activated to CCN whereas during winter aerosols from biomass burning became larger in size due to the coating of organic aerosols, trace gases and other soluble inorganic species which in turn activated to CCN. High CN and CCN were observed for the air masses arriving from northern, central and eastern part of IGP as well as arid and semi arid regions of west Asian countries during pre-monsoon. On the other hand, high CN and CCN during winter were observed for the air masses arrived from central and eastern part of IGP and Nepal. Moreover, CN concentrations over Darjeeling were found to be much higher (almost or more than double) than Nainital in western Himalaya all the dry seasons.

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 (2016-2017)

Aerosol-Rain Interaction over Eastern Himalaya:

The scavenging of aerosols by precipitation is one of the major mechanisms for maintaining a balance between the sources and sinks of atmospheric particles. The present study is based on the effect of physical characteristics of rain on the aerosol scavenging and acidity of rain samples over Darjeeling, a high altitude (2200 m asl), an Himalayan hill station. Simultaneous collection of PM10, PM2.5 and rain samples were done during monsoon (June to September), 2016 over Darjeeling. The average concentration of PM10 aerosol was found to be 11.4 ± 5.7µg m^{-3} varying between 5.7 µg m^{-3} and 25.5 µg m^{-3} whereas the concentration of fine mode aerosol (PM 2.5) was varying between 1.7 µg m^{-3} and 18.1 µg m^{-3} with an average of 7.3 µg m^{-3} in this

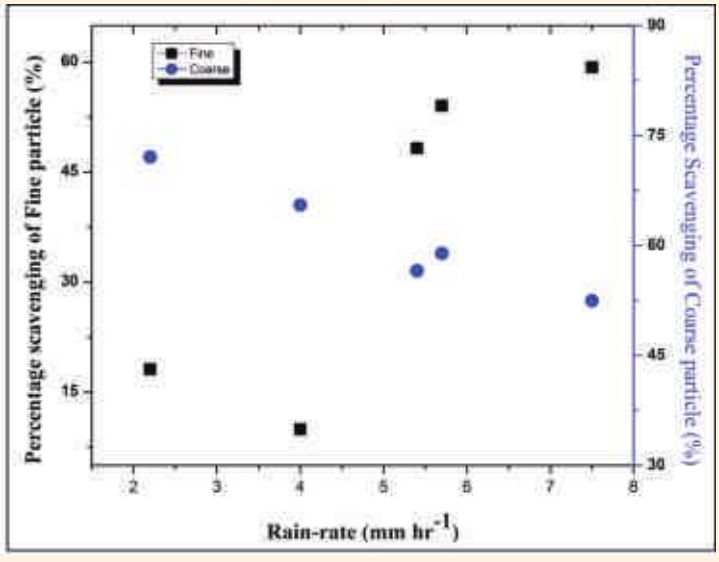


Fig 1: Aerosol scavenging by rain of different intensities

entire study period . SO_4^{2-} and Na^+ are found to be the most abandoned species in both fine and coarse mode during the study period.

Overall 60% of the total rain sample is found to be acidic in the study period. Long-term analysis of precipitation chemistry study (2013-2016) reveals no significant changes in major components of rainwater as well as pH. Very high Scavenging ratio was observed for NH_4^+ in both fine and coarse mode compare to other anthropogenic components indicates presence of gas phase ammonia during the study period. Further investigation on rainwater acidity reveals that scavenging of gaseous NH_3 has major contribution in neutralizing rainwater acidity over Darjeeling. Chemical composition of aerosol before rain event during rain event and after rain event indicate rain intensity played a major role in aerosol scavenging in fine mode and coarse mode aerosol. It was observed that high scavenging of coarser mode aerosol was observed in low rain-rate (< 5.0 mm hr^{-1}). On the other hand, fine mode aerosol scavenged well by higher rain-rate (> 5.0 mm hr^{-1}). Higher concentration of coarse mode sea-salt particles during rain indicates presence of low cloud in the sampling area. Scavenging and regeneration of fine and coarse mode aerosol were found to be different for different rain rate.

Long-term study of cloud condensation nuclei (CCN) activation of atmospheric aerosols over eastern Himalaya in India:

Cloud droplets in the atmosphere formed by condensation of supersaturated water vapor on aerosol particles. A subset of aerosol that provides the surface for this condensation is called Cloud Condensation Nuclei (CCN). The ability of aerosol to work as CCN is depends upon its size as well as its chemical composition. In our present study we have measured condensation nuclei (CN) and

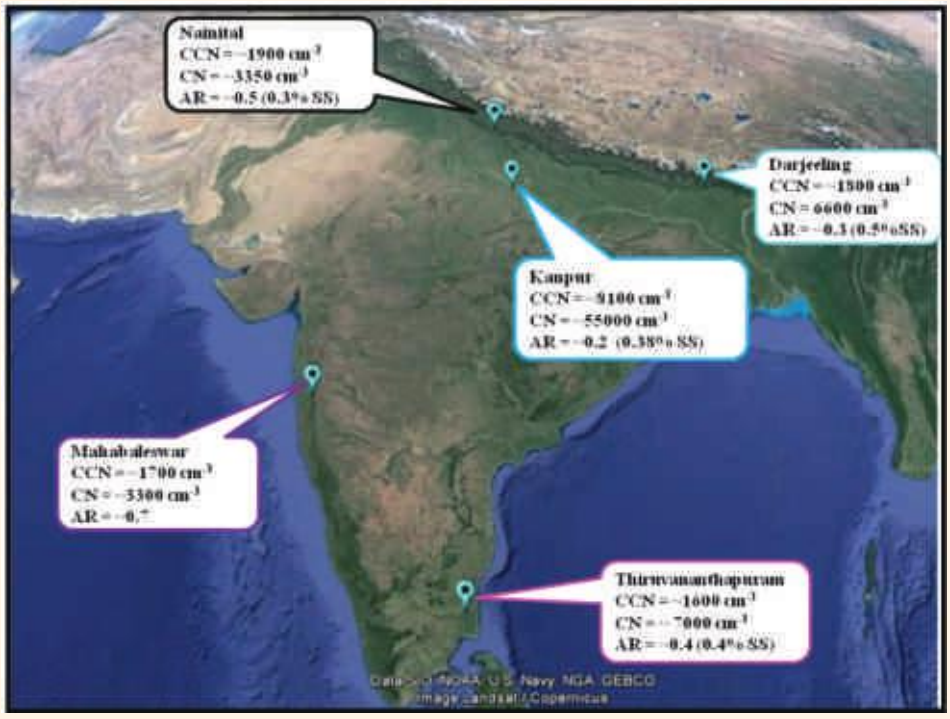


Fig 2: Aerosol-Cloud Condensation Nuclei activation over India

cloud condensation nuclei (CCN) over Darjeeling (27.03°N, 88.26° E), a high altitude hill station over eastern Himalaya (~ 2200 amsl) during dry seasons (2015-2016).

The number concentrations of CN ranged between 694 and 23,643 cm^{-3} with an average of 6563 ± 2160 cm^{-3} whereas that of CCN (at 0.5% super saturation) ranged between 262 and 13,382 cm^{-3} with an average of 1761 ± 856 cm^{-3} during the entire study period. Overall, 30–32% aerosols were observed to activate to CCN during winter and premonsoon whereas 24% activation was observed during postmonsoon. The diurnal variation of AR over Darjeeling shows higher values during late night to early morning hours (2100–0600 h) with the peaks at ~ 0400 h in all the seasons. Hygroscopicity parameter (k) calculated from CCN concentration at different supersaturation, reveals presence of aerosol particle with higher hygroscopicty during premonsoon. High CN and CCN were observed for the air masses arriving from northern, central and eastern part of IGP as well as arid and semi arid regions of west Asian countries during premonsoon. On the other hand, high CN and CCN during winter were observed for the air masses arrived from central and eastern part of IGP and Nepal. What we observed is that CN concentrations over Darjeeling were much higher (almost or more than double) than Nainital in western Himalaya all the dry seasons. Overall, we observed that submicron aerosols became more hygroscopic during their transport by external mixing during premonsoon, which in turn got activated to CCN whereas during winter aerosols from biomass burning became larger in size due to the coating of organic aerosols, trace gases and other soluble inorganic species which in turn activated to CCN.

Effect of Shifting Cultivation Activity over Eastern Ghat and Adjacent Places on the Air Quality of Kolkata

The current practice of shifting cultivation in Eastern Ghat regions is an extravagant and unscientific form of land use. The evil effects of shifting cultivation are devastating and far-reaching in degrading the environment and ecology of this part. This has resulted in large-scale deforestation, soil and nutrient loss, and invasion by weeds and other species and massive deterioration of air quality in nearby and adjacent places. The study shows influence of downwind transported bio mass burning aerosols of Eastern Ghat and adjacent areas due to shifting cultivation activity on the air quality of a tropical urban atmosphere in Eastern India. During Pre-monsoon time particulate pollution remains less than post monsoon or winter over the whole IGP region because of the advection of the pollutant by intense solar heating. But due of the continuous flow of the transported bio mass burned aerosol, the concentration of aerosols over Kolkata was higher in April than May. The size segregated study reveals that the fine mode particles were high during burning period than the normal days. The aerosol mass distribution spectrum shows a bi modal distribution pattern over Kolkata in April with two distinguish peaks one in a fine mode and the other in coarse mode. On the other hand during May a trimodal distribution pattern was observed. Non-sea fine mode potassium shows a fourfold increased value during fire events than the normal days which clearly indicates the influence of bio mass burn plume over Kolkata. The other water soluble species like sulfate, nitrate, and ammonium also shows increase value during the fire events. Thick aerosol layers mixed with polluted dust and smoke was observed from CALIPSO which further more indicate the bio mass burned plume over the Kolkata. Presence of elevated amount of absorbing aerosols during the fire events was also observed from high value of Absorbing aerosol

optical depth and UV-Aerosol Index. This furthermore clarifies the presence of soot and brown carbon over Kolkata during the fire events.

Polycyclic aromatic hydrocarbons in ambient air of Kolkata and Darjeeling

Polycyclic aromatic hydrocarbons (PAHs) are unpreventable byproducts of any kind of fuel and biomass combustion. Substantial impacts of PAHs have been documented on the ecosystem including human in terms of their cytotoxic effects including interruption of normal functioning of cell membrane and associated enzyme system, intensified inflammatory response, immunosupression, teratogenicity, carcinogenicity and mutagenicity to induce DNA-adduct formation. Hence, monitoring of the near surface atmospheric load of PAHs is utmost necessary. Therefore the current load of polycyclic aromatic hydrocarbons intrinsic to airborne fine (particulate aerodynamic diameter range 0.1 to 2.5 µm) and coarse (particulate aerodynamic diameter range 2.5 to 10 µm) particulate matter was measured systematically over Kolkata (c_{PAH} = ~ 90 ngm^{-3}) vis-à-vis over Darjeeling (c_{PAH} = ~ 20 ngm^{-3}), for the first time in the eastern Himalaya. Apart from meteorological influences, the socioeconomically and geographically different environments reflect prominently distinct air concentration values of PAHs over those stations. Additionally, the concentration values have been found to be comparable to other Indian cities and the atmospheric PAH load seems to be reduced in comparison to the earlier studies at Kolkata. However, 40–60% contribution of probable human carcinogens to the total-PAH measured in the current study raises the need to regulate the uncontrolled combustions and implementation of cleaner fuel in the public transport.

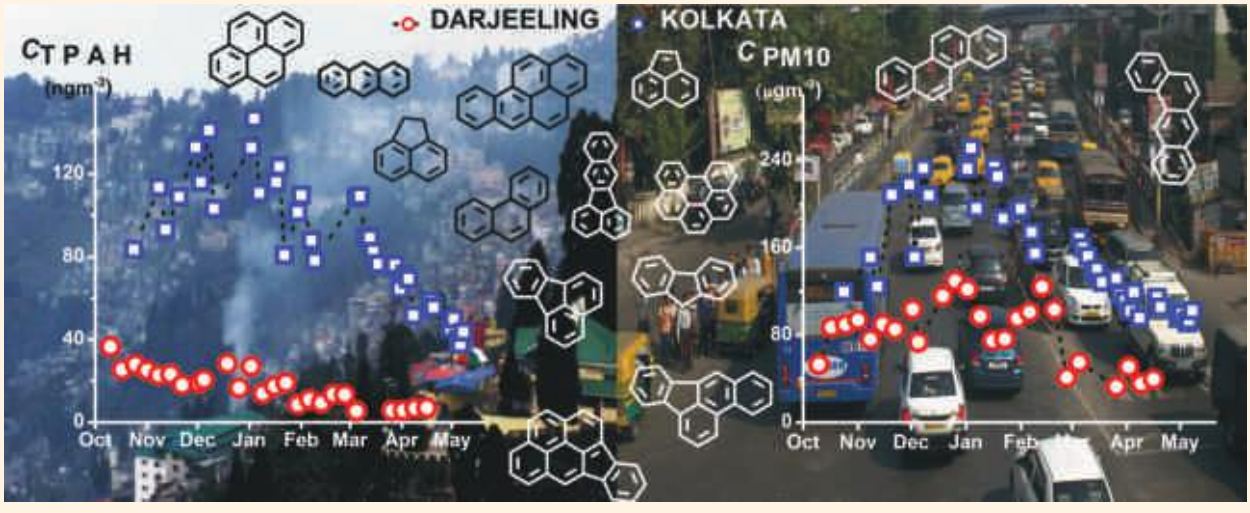
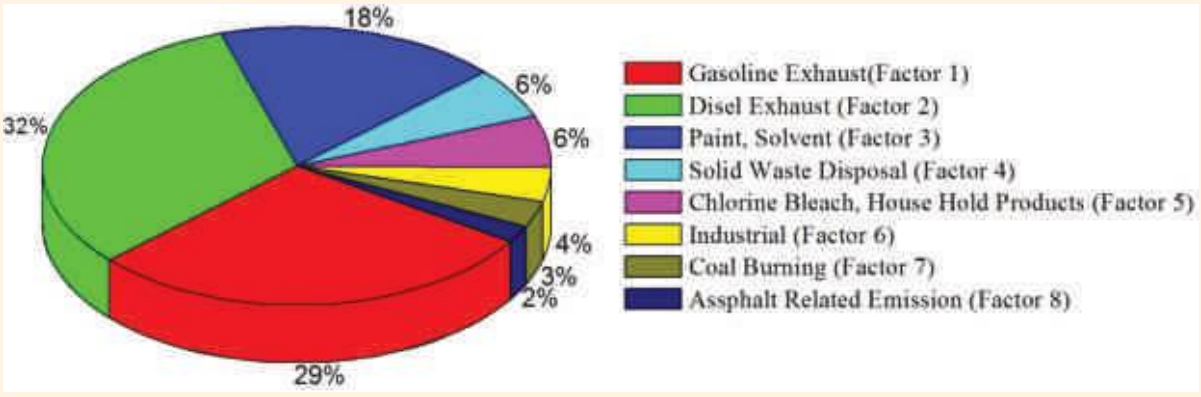


Fig 3: Hazardous carbonaceous aerosol pollutants over Kolkata and Darjeeling

Non-methane carbonaceous hazardous pollutants over eastern Himalaya

The first ever year-long study on atmospheric non methane volatile organic compounds (VOCs) and carbonyl compounds over Indian Himalaya was conducted where samples were collected from a high altitude station, Darjeeling (27.01°N, 88.15°E, 2200 masl). The major findings of the study are as follows:

Major VOCs and carbonyl compounds like benzene, toluene, ethylbenzene, xylene, acetone, formaldehyde and acetaldehyde over Darjeeling were found to be comparable and sometimes higher than some of the metro cities in India and other parts of the world. Both VOCs and carbonyl compounds showed distinct seasonal variation with the maximum concentrations during postmonsoon followed by monsoon, winter ~ premonsoon. Surface reaching solar radiation played major role in photochemical production/degradation of VOCs and carbonyl compounds over Darjeeling. In spite of higher vehicular activities, photochemical degradation due to higher solar radiation flux reduced the atmospheric loading of VOCs and carbonyl compounds during premonsoon. On the other hand, low solar radiation along with higher vehicular activities helped in accumulating VOCs and carbonyl compounds during postmonsoon. Higher ozone formation potential suggests that more tropospheric ozone could be produced through the oxidation of volatile organic compounds during postmonsoon. Different sources of VOCs and carbonyls were identified over the study area, among them vehicular emission (gasoline and diesel exhaust), solvent evaporation, biogenic emissions from tea plantation and poor waste management system were the major sources of VOCs and carbonyl compounds over Darjeeling. The high atmospheric loading of VOCs and carbonyl compounds over Darjeeling is of a serious concern from the point of view of human health and sensitive ecosystem over this part of Indian Himalaya. Thus it is



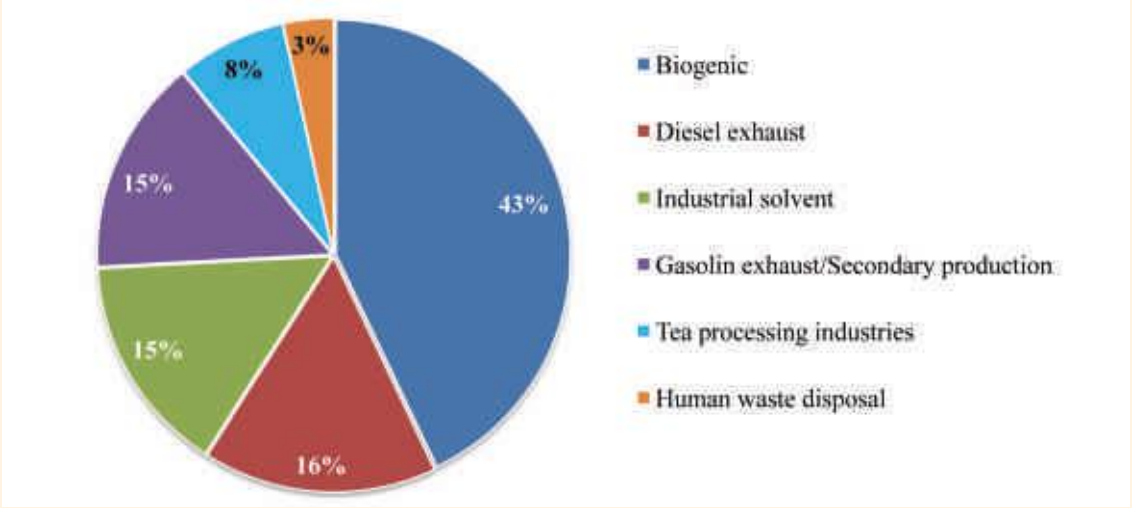


Figure. 4. Sources of (a) Volatile organic compounds and (b) carbonyl compounds over Darjeeling

imperative to control vehicular pollution, solvent usage, adopt proper and scientific waste management system to mitigate these potentially carcinogenic pollutants over Darjeeling.

The first ever long term study on trend of PM 2.5 and BC concentration and effects of various micrometeorological parameters and transportation patterns on the long term trend of these pollutants over an Himalayan hill station are summaries below:

The air quality over the hill station, Darjeeling is improving regarding fine aerosol and BC pollution over the study area. As a whole PM 2.5 concentration decreased 49% and BC concentration decrease 34% from the year 2009 to 2015 at a rate of 0.2 $\mu gm^{-3}month^{-1}$ and 0.02 $\mu gm^{-3}month^{-1}$ for PM2.5 and BC respectively . Strong seasonality was observed for both PM2.5 and BC mass concentration. Maximum loading for both the pollutants ware observed during the month of March in the premonsoon season and minimum during the month of July/August (monsoon season). High atmospheric loading of PM2.5 and BC during premonsoon season was attributed to high vehicular emission and other anthropogenic activities related to peak tourist season along with favourable meteorological conditions. Heavy rainfall during monsoon season washed out the pollutants from the atmosphere causing minimum pollutant concentration during this season. Surface Wind Speed (WS) and Mixing Layer Depth (MLD) played a major role on pollutant concentration over Darjeeling. Significant positive correlation was found between these two parameters and pollutant concentration. High wind speed and elevated MLD helped pollutants to transport from long distant regions as well as from polluted foothill regions of Himalaya. A decreasing trend in ΔT, MLD and WS was the main meteorological effect to govern the pollutant concentration over the study area. Indo Gangetic Plane (IGP) and Nepal was identified as the main contributing source regions for both PM2.5 and BC. A change in transportation pattern was also observed that might also affect the

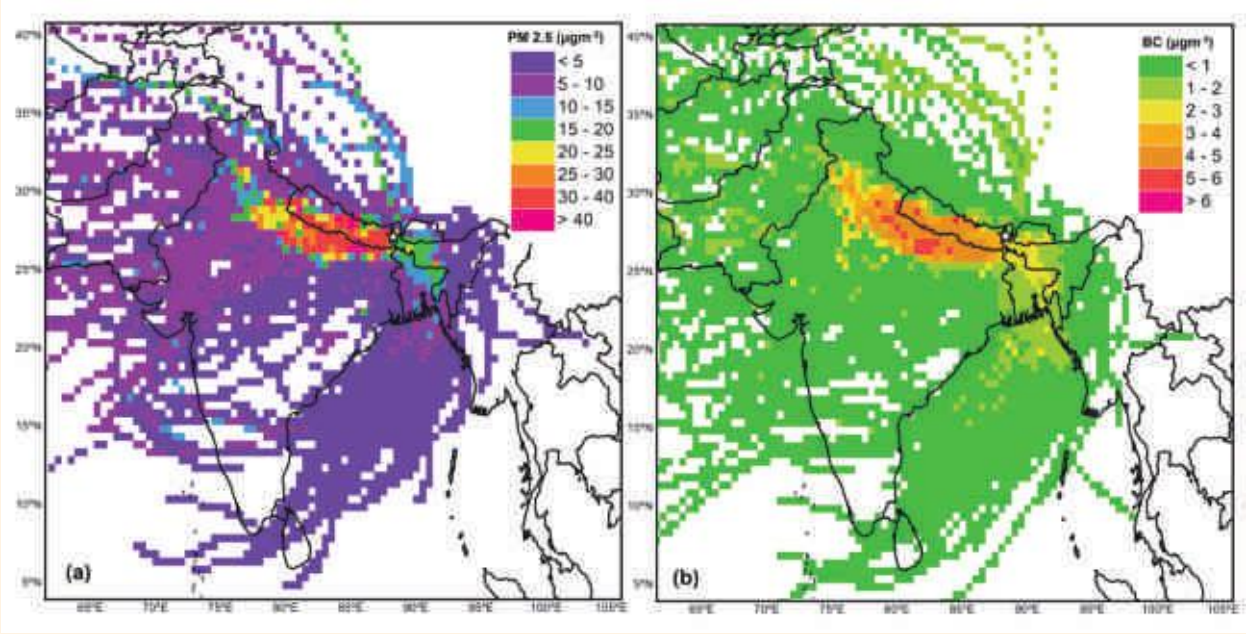


Figure 5. PM2.5 (a) and BC (b) contribution from different source regions towards Darjeeling, identified by CWT model analysis during the entire study period.

pollution loading over the study area. The contribution from IGP and Nepal regarding pollutants transport was decreased where as local contribution on pollutants loading was increased. A decreasing trend of open burning over IGP and Nepal was also observed from MODIS satellite observation that might also have an effect on the decreasing pollutant transport from these source regions.

Grants-in-Aid Schemes :

Title of the Scheme	Schemes funded by
As Principal Investigator of one program and as co-PI of other programs Study of Cosmic ray interactions and Cosmic Ray – Aerosol – Cloud connection in the context of regional climate change	DST, Govt. of India
As Principal Investigator Study on Biosphere-Atmosphere Exchange of Carbon dioxide, Water Vapor and Energy in a Tropical High Altitude Forest Canopy at Eastern Himalaya, India	MoES, Govt of India
As Principal Investigator National Carbonaceous Aerosol Program (NCAP)	MoEFCC, Govt of India

Publications :

- Roy A , Chatterjee A, Sarkar C, Kumar Das S, Ghosh S Kumar and Raha S (2017) A study on aerosol-cloud condensation nuclei (CCN) activation over eastern Himalaya in India. *Atmospheric Research* (IF:3.377), 189, 69-81.
- Sen A, Nazeer Ahammed Y, Mansour A Alghamdi, Banerjee T , Ahmad Bhat M, Chatterjee A , Choudhuri A K, Dhir A, Das T, Gadi R, Ghosh S, Khan AH, Maharaj Kumari K, Chandra Kuniyal J , Lakhani A , Naja M, Pal D, Pal S, Ramshoo S, Rashid I, Saikia P, Shenoy DM, Sridhar V, Verma N, Vyas B M, Saxena M, Sharma S K, Sharma A and Mandal T K (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* (IF: 3.459), 154, 200-224.

Falta Experimental Farm

One day training programme was organized on "Vermicompost Production" at Bhulabeda village, Binpur 2 Developmental Block, Paschim Medinipur on 9th July 2016. On request of ADO Mahammadbazar Block, Birbhum a two-day training programme was organized on Bee-keeping during July 24-25, 2016 under the "Atma" programme and 18 farmers were trained. One training programme was organized on "Rain water harvesting for drinking purpose" during July 25-29, 2016 for students and staffs (5 participants) of Dinabandhu Mahavidyalay, Bangaon, North 24 Parganas on request of the college authority. During 18th-24th September, 2016 a Refresher Course on Different Rural Biotechnology Programmes was organized at Falta Experimental Farm for Onsite Trainers (14 participants) working in different NGOs under the Scheduled Tribe-Specific Rural Biotechnology Programme. Four Awareness Camps on Different Income Generation Programmes for Scheduled Tribe Beneficiaries were organized during the year (Satyadaspur village, Patharpratima Block, Sunderban on 08.06.2016, Chhachanpur village, Chhatna Block, Bankura on 08.11.2016, Bhutadih village, Manbazar 2 Block, Purulia on 09.11.2016 and Amlasol village, Binpur 2 Block, Paschim Medinipur on 10.11.2016) and about 600 tribal people participated in those awareness camps.

In the FY 2016-2017 ten Animal Health Camps were organized under the Scheduled Tribe-Specific Rural Biotechnology Programme in different project sites. Our Resource persons, veterinary surgeon Dr. Nihar Kanti 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.	20.05.16	Maniardi, Paschim Medinipur	55	08	397	--	--	405
2.	26.05.16	Chakadoba & Kashmar, Paschim Medinipur	63	112	162	--	--	274
3.	08.06.16	Amlasole, Kankrajhor & Bagdoba, Paschim Medinipur	43	53	229	--	--	282
4.	16.06.16	Chhhachanpur, Chhatna, Bankura	50	167	177	--	160	504
5.	17.06.16	Shihikapahari, Chhatna, Bankura	59	172	341	47	412	972
6.	21.07.16	Satyadaspur, G-Plot, Patharpratima, South 24 Parganas	47	86	120	22	411	639
7.	21.07.16	Krishnadaspur, G-Plot, Patharpratima, South 24 Parganas	18	43	37	31	102	213
8.	22.07.16	Sabuj Bazar, G-Plot, Patharpratima, South 24 Parganas	32	158	176	27	235	596
9.	27.08.16	Khansahebabad & Khasramkar, Sagar Island, South 24 Parganas	89	196	202	92	1281	1771
10.	28.08.16	Gangasagar, Sagar Island, South 24 Parganas	91	224	279	37	965	1505
		TOTAL	547	1219	2120	256	3566	7161

The following Table depicts the year-round activity done through different NGOs (NGO mode) and through departmental machinery of Bose Institute (Direct mode) in the FY 2016-2017

Sl. No.	Name of the Programmes	No. of Units Done by NGO mode	Done by Direct mode	Total
1.	Chicken rearing	87	149	236
2.	Duck rearing	46	0	46
3.	Goat rearing	212	43	255
4.	Sheep rearing	5	0	5
5.	Pig rearing	47	29	76
6.	Fishery	23	49	72
7.	Bee-keeping	19	2	21
8.	Mushroom	19	42	61
9.	Vermicompost	33	10	43
10.	Agriculture (in bigha)	11	388	399
11.	Kitchen gardening	75	29	104
12.	Orchard (in bigha)	7	129	136
13.	Concrete Tank for rainwater harvesting for drinking	88	21	109
14.	Polypond for rainwater harvesting for irrigation	5	30	35
15.	Food processing	1	0	1
16.	Palm Patali	1	0	1
17.	Mahuya Naru	1	0	1
18.	Crab Culture	1	16	17
19.	Betel Leaf Cultivation	0	3	3
20.	Sericulture	0	2	2
	Total	681	942	1,623

Some programme-wise photographs and brief descriptions are given below:

Fig. 1: Glimpses of some awareness programmes. a) Prof. S.R. Sikdar was garlanding the photo of Acharya J.C. Bose on the onset of the awareness programmeon 08.11.2016 at Bhutadhi village, Block: Manbazar 2, Purulia. b) The view of the audience gathered during the awareness programme mentioned in (a). c) Mrs. Srabani Sikdar, Resource person in the Rural Biotechnology Programme was distributing hand sprayer to the beneficiaries involved in the kitchen gardening programme during the awareness programme at Chhachanpur village, Block: Chhatna, Bankura on 07.11.2016. d) Prof. Sikdar was addressing to the audience during the awareness programme at Chhachanpur village, Block: Chhatna, Bankura on 07.11.2016.

Animal Health Camp:

Fig. 2: Photographs of different activities of Animal Health Camp. a) Dr. Asim Prasad Chattopadhyay and other project personnel were distributing medicines to the beneficiaries for their domestic animals at Gangasagar village, Sagar Island, South 24-Parganas on 28.08.2016; b) Dr. Nihar Kanti Ghosh, resource person Bose Institute and other officials from Animal Resource Department, Chhatna Block, Bankura were conducting animal health camp at Shihikapahari village on 17.06.2016; c) Vaccination was going on to the cattle at Shihikapahari village, Bankura; d) Tribal beneficiaries were enrolling their domestic animals in the animal health camp office at Chhachanpur village, Chhatna Block, Bankura on 16.07.2016. Ten Animal Health Camps were organized in 2016-17 and 547 beneficiaries brought their domestic animals (7,161 Nos) in the camps and the animals were either vaccinated or provided with preventive medicines.

Rain water harvesting for drinking & irrigation purpose:

Fig. 3: a) During the awareness camp at Bhutadhi village, Purulia on 08.11.2016 villagers from neighbouring villages who came to attend the awareness camp were observing the polypond system. b) In the same camp, the neighbouring villagers were observing the rain water harvesting concrete tanks constructed along the side of the main road of the village one tank for each family. c) Mr. Sobhan Roy Chowdhury, Sr. Technical Assistant was demonstrating rain water harvesting for drinking purpose to the participant villagers who attended the awareness camp at Bhutadhi village. d) Mrs. Srabani Sikdar, one of our resource persons was demonstrating rain water harvesting for drinking purpose to the participant villagers who attended the awareness camp at Chhachanpur village, Bankura, held on 07.11.2016.

Vermicompost Programme:

Fig. 4 a) Prof. S.R. Sikdar, Coordinator Rural Biotechnology Programme was visiting vermicompost unit implemented through the NGO, Alor Sparsa Welfare Society at Birbhum; b) Mr. Sobhan Roy Chowdhury was demonstrating vermicompost production to the Ph.D. course work students of our Institute at Falta Experimental Farm; c) The field supervisor and the beneficiary were standing infront of the vermicompost unit implemented by the NGO, Ghosaldanga Adibasi Seva Sangha; d) School students in the tribal area were also trained on vermicompost production; two tribal students were standing with earthworm in their hands in front of the vermicompost unit of Mr. Ranjit Mandi (Purulia) developed under the Scheduled Tribe-Specific Rural Biotechnology Programme of Bose Institute.

Kitchen Garden & Vegetable Cultivation Programme :

Fig. 5. a) The tribal beneficiaries who participated in the kitchen gardening programme were standing infront of a kitchen garden developed under this project at Chhachanpur village, Bankura; b) Our project staffs were visiting a vegetable cultivation field developed under this project at Purulia; c) A vegetable cultivation field at Paschim Medinipur developed under Scheduled Tribe specific Rural Biotechnology Programme; d) Beneficiaries were preparing seed bed for kitchen gardening and vegetable cultivation programme at Purulia

Orchard Programme:

Fig. 6: Different activities on orchard programme. a) Tribal beneficiaries were working during the plantation of orchard saplings at Tamakhun village, Purulia; b) The Auditor, Mr. N.K. Biswas who has been appointed to audit the Scheduled Tribe-Specific Rural Biotechnology Programme Project was visiting two year old orchard at Bankura along with the project personnel; c) Our team was visiting a year old mango orchard developed in a rocky fallow land at Basantapur, Purulia; d) Women tribal beneficiaries were working during the plantation of orchard saplings in a village at Purulia;

Agriculture Programme:

Fig. 7: a) A betel leaf cultivation baroj developed from the project in Krishnadaspur village, Sunderban, South 24 Parganas; b) The beneficiary and his son were harvesting green chilli crop at Satyadaspur village, G-Plot, Patharpratima Block, Sunderban, South 24 Parganas.

Animal Husbandry Programme:

Fig. 8: Photographs of Animal Husbandry Programme at different project sites. a) A tribal beneficiary was standing in front of her pig stay at Paschim Medinipur; b) A tribal beneficiary was taking care of his croilar chickens provided from the project at Sagar Island, South 24 Parganas; c) The tribal beneficiary was holding his newly obtained goats during the distribution of goat from the project at Satyadaspur village, South 24 Parganas; d) Our project staff was distributing ducklings to the tribal beneficiary in a village at Sunderban, South 24 Parganas.

Mushroom cultivation programme:

Fig. 9: a) Oyster mushroom bed preparation was demonstrating to the tribal beneficiaries during the awareness camp on 07.11.2016 at Chhachanpur village, Bankura; b) School students were being demonstrated about oyster mushroom bed preparation by the tribal beneficiaries in a village at Purulia.

Fishery & Crab Cultivation Programme:

Fig. 10: a) Tribal beneficiaries who were given support in the fishery programme from the project were showing their harvested fishes in a village at Sunderban, South 24 Parganas; b) The tribal beneficiary along with his harvested crabs in a village at Sunderban, South 24 Parganas.

Bee-keeping programme:

Fig. 11: a), Mr. Santanu Haldar, Master trainer in the project was checking the bee-box during visit to NGO site at Birbhum; b) Photograph of demonstration training on bee-keeping at our Falta Experimental Farm.

Food Processing, Handicrafts and Cloth Distribution Programme:

Fig. 12: a) A tribal beneficiary was preparing "Palm Patali" through an NGO working under this project in a village at Birbhum; b) Our master trainers were providing training to the tribal women beneficiaries about handicrafts items at Bhutadhi village, Purulia; c) One tribal beneficiary was showing her dried tomato prepared from tomato pulp in the food processing programme at Bhutadhi village, Purulia; d) Mrs. Sikdar and our project staff were distributing clothes among the villagers at Bhutadhi village.

Participation in Poush Mela and Foundation Day of Bose Institute:

Fig. 13. a) Bose Institute participated in Poush Mela 2016 at Santiniketan. Photograph showing preparation of inauguration programme in front the 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 we were participating in the Foundation day of Bose Institute through demonstration of our Scheduled tribe-Specific Rural Biotechnology Programme by displaying posters and live models. Last year on 30th November 2016 our Officiating Director, Prof. Siddhartha Roy along with Prof. Dipankar Home were visiting our 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:

Ishani Chattetjee (J.C. Bose Centre) i) presented paper entitled "Museumization of Sacred Groves: an aid to Heritage Conservation" at the 3-day All India Museums Conference held at Gujarat during 30.01.17 to 2.02.17.

T. K. Maji, I. Chatterjee (J.C. Bose Centre) participated at i) the 20th National Science Exhibition at Surer Math, Dumdum during 10.08.16 to 14.08.16.

ii) National Exhibition-cum- Fair 2015 at KMDA Mela Ground, Patuli held during 29.08.16 to 02.09.16.

Somnath Das, T. K. Maji, I. Chatterjee and Rajbrat Ram participated in the India International Science Festival (IISF-2016) at National Physical Laboratory, Pusa, New Delhi held during 07.12.16 to 11.12.16.

Publications :

Chatterjee I (2016) Cultural Heritage of Bishnupur: A Study on Conservation Approach of Archaeological Survey of India, *J. of Indian Museums*, LXX: 50-53.

Chatterjee I (2016) Acharya Jagadis Chandra Bose Museum- a unique Research Institute Museum , *J. of Dept. of Museology Vol 11&12,* 2016, CU, 215-219.

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 2016
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 2016-2017:

- Book(s) added in 2016-2017 : 52 nos.
- Thesis added : 47 nos.
- Bound Volumes of Journal added : 400 nos.

E. Available Back Volume Journals:

Elsevier Backfiles on ScienceDirect	Wiley Blackwell Journal Back files
1. Biochemistry, Genetics and Molecular Biology	1. Biotechnology, Biochemistry and Biophysics
2. High Energy Physics	2. Physics
3. Cell Press	3. Immunology
	4. Microbiology

F. e-Books added from 2013-2014 :

E-Books

Oxford Scholarship Online Physics Titles

- OSO Con Framework Quantum Field
- OSO Conductor Insulat Qua Phas Trans
- OSO Luminesc Spectroscopy Of Semico
- OSO Many-Body Phy With Ul Cold Gases
- OSO Nicolas-Louis De La Cai Astr Geo
- OSO Niels Bohr & The Quantum Atom
- OSO Non-Equilibrium Ther & Stat Mech
- OSO Quant Theo Small To Large Scales
- OSO Stellar Magnetism 2e
- OSO Story Of Semiconductors

G. Scientific Softwares Available:

Sl. No.	Software(s)	Publishers
1.	Grammarly@edu writing support Suite	Kite India
2.	Pathway Studio Mammal 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.

H. Resources through NKRC (http://nkrc.niscair.res.in/indexpage.php)

Library has joined with the National Knowledge Resource Consortia (NKRC) since 2008 which is joint consortia of CSIR and DST Institutes for accessing online resources. Through this consortia faculty members/scholars of this institute can access more than 5000+ online resources, SCIFINDER, ACS, Web of Science, Patent databases etc. Library could fulfill faculty / scholar demands for article resources from CSIR / DST Institutes subscribed journals. BI Library also provides article resources to all faculty/ scholars of DST / CSIR Institutes and also other institutes in India. Library is also member of FORSA Consortia.

Services and Management

Collection	Total Nos. as on 31 March 2015
Books Issued	210
Bound Volume Journal Issued	104
Loose Journal Issued	122
No. of Readers	5330
Internet Accessed (in hours)	21332
Photocopies	30000 app.
Download of Articles (from Online Journals) (Approx.)	200000+

Services :

Reader's Service	The library is open to faculty member and scholars for reading and consultation during institute working hours. Faculty members / scholars can access (24x7) E-resources from any of the seven campuses of Bose Institute.Faculty members also can access E-resources from off campuses/ home access (24x7).
Technical Query Service	Library responds to any query related to information regarding research insights, reference management, database(s) access, Software services or any access related issues of subscribed content or using Library OPAC/IDR etc.
Document Delivery Service	Library provides article resources to all faculty/ scholars of DST / CSIR Institutes and also other institutes in India.
Inter Library Loan Service	The library provides 'Inter Library Loan' facility to the users of other libraries mostly research institutes who have Inter Library Loan arrangement(s) with Bose Institute Library. Library also get book through inter library book loan.
Institutional Membership	The library is member of various National and International organization(s) (i) Biomed Central (BMC), (ii) British Council Library, (iii) *International Federation of Library Associations* and Institutions (*IFLA), (iv)* International Society of Tea Science (ISTS), (v) *Indian Association Of Special Libraries And Information Centres (IASLIC), (vi) Indian Science Congress Association (ISCA) Membership etc.*
e - Journals Access	The library provides access to electronic journals subscribed by Library as well as subscribed through National Knowledge Resource Consortia (NKRC).
User Awareness Programme	Library conducts user orientation programmes time to time for the benefit of users and optimal utilization of subscribed resources. User orientation programme also includes "Reference management" for publications, citing references in thesis, using databases, citation report, h-index compilation, using different scientific software, using of anti-plagiarism software, grammar checking software etc.
Reprographic Service	The library provides reprography services to its users. Photocopy services are provided to all research workers of the Instiute. A total 2,90,607 pages of photocopies were given to our faculty and outside users.

Off-Campus access to BI e-resources

This year library has subscribed to RemoteXS hosting service to cater our scientists / researchers for off-campus access facility of journals , e-books etc.

National Digital Library (NDL)

Our library is now working as a part of National Digital Library, a project of IIT, Kharagpur. We have already shared the following resources from our repository:

1 > J C Bose Collection

2 > Annual Reports

3 > BI Newsletters

4 > Science Congress 2012 News

We are in the process of sharing other publications of Bose Institute.

Academic Programmes / Seminar Organised by BI Library :

Bose Institute Library regularly organizing number of academic programmes for researchers of Bose Institute as well as nearby research institute(s) for promoting usage of Bose Institute Library subscribed resources as well as NKRC subscribed resources. These workshop(s) / training programme(s) also help scholars to lessen their research time. A good number of training programmes are organsied for using databases, software etc. Library helps to all kind of research endeavor.

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 ,Library In Charge, attended National Knowledge Resources Consortium(NKRC) Nodal Officers Meet 2016 held at CSIR-NISCARE,New Delhi on 29-30 August,2016.

A workshop "One Team One Dream" was organized on 17th Dec 2016 at Falta Experimental Farm.

Attendees from library - Ms. Ananya Raha

. Ms. Sumita Dey

Mr. Mrityunjoy Jogsharma

New Initiative :

RFID Project : Stock verification is an important part of any library , particularly for an old establishment like Bose Institute Library. To solve this problem, this year library is going to implement RFID technology which will fully digitize Bose Institute Library. The project has already been initiated and work is going on till date. We expect to finish this project by this financial year.

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.

i) 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 are being manufactured against the requisitions of internal Scientist and Officers.

ii) Carpentry Section- This section deals with all furniture manufacturing, repairing jobs etc as per the requirements of Scientists, officers etc. Some significant jobs like fabrication of wooden parts of Sir J.C.Bose instruments etc. have also been carried out in this section.

iii) Store- Workshop store maintains the materials (Civil, Electrical, Mechanical ,Plumbing, Building and Furniture related materials etc). required for all seven campuses.

iv) 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.

v) 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 16-17 :-

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

LIST OF PERSONNEL

Administration

Dr. Siddhartha Roy, *Sr. Professor & Director (Officiating)*

Dr. Samir Ranjan Sikdar, *Sr. Professor & In-charge, Registrar's Office*

Smt. Noreen Bhattacharjee, *Deputy Registrar*

Centenary Campus: Subir Sen, Sougata Banerjee, Achintya Mukherjee, Ashim Kr. Biswas, Sisir Chakraborty, Manick Ch. Das, Baladeb Goswami, Rina Roy, Dhrubajyoti Sen, Mantu Bhattacharjee, Vinit Tandon, Debdas Nandi, Somnath Das, Kamal Singh, Supriya Das, Satya Swarup Behera, Ananya Malgope, Rubi Sarkar, Sudam Jana, Bably Marick, Rina Das, Sanjoy Krishna Chaki, Debasis Kaley, Angshuman Bhowmik, Biplab Malakar, Shaubhik Ghosh, Arpita Bose, Mahendra Nath Shee, Hemanta Kumar Sahoo, Goutam Behera, Gouranga Paramanik, Animesh Jana, Ratan Saha, Sumanta Ghosh, Satyabrata Chatterjee, Khoirul Basar Malla, Kanai Hazra, Prafulla Bhunya, Kanak Baran Hazra, Duryodhan Nayak, Bablu Mandal, Sukanta Chakraborty, Subrata Banerjee, Ranjit Das, Sukumar Mandal, Jagabandhu Nayak.

Main Campus: Tarun Kumar Maji, Amitabha Bhattacharjee, Ishani Chatterjee, Chandra Kanta Sasmal, Rajbrat Ram, Sarada Devi, Madhusudhan Marick, Sanat Kr. Dhara, Kalicharan Turi, Munna Turi. Kodan Das, Rajkumari Balmiki.

Acharya J.C. Bose Biotechnology Innovation Centre

(Madhyamgram Experimental Farm)

Faculty: Prof. Siddharta Roy (Director and Chairman), Dr. Gaurab Gangopadhyay (Scientist-In-Charge)

Staff Members: (Office): Mr. Amit Kumar Ghosh

Staff Members: (Lab.): Mr Asis Kumar Dalal

Staff Members: (Field): Mr Pulak Kumar Roy, Mr Rabin Talukder, Mr Laxmi Kanta Pradhan, Sk Inal Ali, Mr Mahesh Dasgupta, Mr Bhanu Kisk

Research personnel (project):

Dr. Priyanka Das (RA), 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 (Sr. Professor & Chairman), Prof. Anuradha Lohia, Sr. Professor (retired on 30.06.16), Prof. Rajagopal Chattopadhyaya, Professor, Prof. Pradeep Kumar Parrack, Professor (retired on 28.02.17), Dr. Subrata Sau, Professor, Dr. Srimonti Sarkar, Associate 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, Ms. Gopa Dhar (terminated on 31.07.16), Mr. Anindya Biswas (terminated on 15.12.16), Ms. Sayani Sarkar (terminated on 28.02.17), Ms. Prerana Agarwal (terminated on 28.02.17), Mr. Aditya Prasad Behera, Mr. Sukhendu Mondal, Mr. Shankari Prasad Datta, Mr. Soumitra Polley, Ms. Nabanita Saha, Ms. Atrayee Ray, Ms. Shamila Sarwar, Mr. Supriyo Bera, Mr. Pritam Naskar, Mr. Mousam Roy, Mr. Swapan Kumar Jana (joined on 01.06.16), Mr. Soham Seal, Ms. Chandrima Bhattacharyya, Mr. Debabrata Sinha, Mr. Shayantan Mukherji, Ms. Somi Patranabis (joined on 01.07.16), Ms. Shreyasi Dutta (joined on 07.09.16), Mr. Dhritiman Dey (joined on 31.01.17), Ms. Ivy Mallick (resigned on 30.09.16), Dr. Chumki Bhattacharjee (joined on 15.03.17)

Staff Members : Mr. Subhash Chakraborty, Mr. Asim Kumar Poddar, Mrs. Debarati Kanjilal, Md. Asraf Ali Molla (superannuation on 30.11.16), Mr. Dulal Chandra Mondal, Ms. Ranubala Das (superannuation on 31.01.176), Mr. Atanu Pramanik, Mr. Tuhin Saha

Bioinformatics Centre

Faculty: Dr. Pinakpani Chakrabarti, Scientist-In-Charge, Dr. Tapash Chandra Ghosh, Sr. Professor Dr. Shubhra Ghosh Dastidar, Associate Professor, Dr. Zhumur Ghosh, Asstt. Professor, Dr. Sudipto Saha, Asstt. Professor.

Students /RA /Project Assistant : Kamalika Sen (DST-SERB SCI.), Atanu Maity, Arijita Sarkar , Sohini Chakraborty, Prerna Priya, Debarun Acharya, Ranjan Kr. Maji, Sarmistha Majumdar, Kakoli Biswas, Tonmoy Jana, Souvik Sinha,Debashree Sarkar, Jesmita Dhar, Aritra Deb, Sibun Parida, Sreyashi Majumdar, Avisek Mondal, Manish Prakash Victor, Debangana Chakrabarty, Saran N. , Abir Pal, Byapti Ghosh, Abhirupa Ghosh, Krishnendu Banerjee, Debadrita Basu.

Staff Members: Mrs. Sujata Roy, Mr.Sanjib Gupta, Mr.Jibananda Mondal.

Biophysics Department

Faculty : Dr. Siddhartha Roy, Professor, Dr. Gautam Basu, Professor, Dr. Anirban Bhunia, Associate Professor, Dr. Subhrangsu Chatterjee, Associate Professor, Dr. Debjani Roy, Assistant Professor, Dr.

Manju Roy, Visiting Scientist, Dr. Smarajit Polley, DBT-Wellcome TrustFellow, Dr. Moitri Basu, DST-Inspire Faculty.

Students/RA/Project Assistant : Mr. Bankim Mondal, Ms. Paulami Chatterjee, Mr. Anirban Ghosh, Mr. Jagannath Jana, Mr. Rajib Kumer Kar, Ms. Aritreyee Datta, Ms. Soma Mondal, Ms. Meghamukta Mukherjee, Ms. Swapna Bera, Ms. Sudakshina Ganguly, Dr. Aparajita Pal, Mr. Anirban Roy, Ms. Ananya Dutta, Mr. Bhisma Narayan Ratha ,Mr. Dr. Aditya Dev, Dr. Piya Ghosh, Dr. Madhumita Chakraborty, Dr. Gitashree Naiya, Ms. Basusree Ghosh, Dr. Raka Ghosh, Ms. Humaira Ilyas, Ms. Sonali Ghosh, Mr. Nayan De, 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. Moupriya Nag, Dr. Debmitra Chakraborty, Ms. Soumi Das, Ms. Monalisa Kundu & Mr. Anindya Dutta.

Staff Members : Basudeb Marick, Barun Majumder, Tanmoy Debnath, Baladeb Goswami, Swapan Joghsharma, Sudhir Turi, Nagnarayan Yadav.

Chemistry Department

Faculty : Dr. Joyoti Basu, Sr. Professor, Dr. Suman Kr. Banik, Asstt. Professor, Dr. K. P. Das, Sr. Professor, Dr. Pradip Das, Professor, Dr. Mmanikuntala Kundu, Sr. Professor & Chairperson, Dr. Jayanta Mukhopadhyay, Asstt. Professor, Dr. Soumen Roy, Asstt. Professor

Students/RA/Project Assistant : Srijon Kaushik Banerjee, Chandreyee Datta, Prasun Sarkar, Ayan Chatterjee, Soumyajyoti Banerjee, Manish Kumar, Sanjoy Kr. Sahoo, Rajdeep Kaur Grewal, Saptarshi Kr. Sinha, Indrani Paul, Arun Kr. Sharma, Arkajyoti Datta, Ayan Biswas, Amar Ch. Mahata

Staff Members: Pranab Dey, Tapas Ghosh, Dipak Ch. Konar, Rama Chatterjee, Sujata Roy, Gaurab Roy, Mrityunjoy Kundu, Subhas Ch. Paul, Asoke Kr. Maity, Sachchidanand Ram

Central Instrumentation Facility

Faculty: Dr. Sujoy K. Das Gupta, Professor& In Charge(Cent. Bldg.), Dr. T. P. Sinha, Professor & In Charge(Main Campus).

Supporting Staff (Cent. Campus): 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 : Dr. Kaushik Biswas, Assistant Professor, Dr. Tanya Das, Professor, Dr. Kuladip Jana, Scientiest-C, Dr. Atin Kumar Mandal, Assistant Professor, Dr. Nripendranath Mandal, Associate Professor, Dr. Subrata Majumdar, Professor, Dr. Anup Kumar Misra, Associate Professor, Dr. Mahadeb Pal, Associate Professor, Dr. Gaurisankar Sa, Professor, Dr. Parimal C. Sen, Senior Professor & Head, Dr. Parames Ch. Sil, Professor.

Students/RA/Project Assistant : Dr. Partha Pratim Bose, Dr. Suchandra Majumdar, Dr. Abhishek Das, Dr. Swatilekha Ghosh, Dr. Ranjita Das, Dr. Syamdas Bandyopadhyay, Dr. Nivedita Roy, Dr. Aparajita Ghosh, Dr. Suman Bhandary, Sourav Panja, Avisek Banerjee, Junaid Jibran Jawad, Bhaswati Banerjee, Manjari Kundu, Poulami Khan, Ananya Dutta, Pritam Sadhukhan, Pramit Bhattacharjee, Baijayanti Ghose, Priyanka Basak, Anirban Manna, Udit Basak, Debasish Dhara, Nilanjan Gayen, Pravat K. Parida, Sayantan Bose, Asif Ali, Ansupriya Si, Sweta Ghosh, Ishani Bhaumik, Dwaipayan Chakraborty, Sendge Anil Khusal Rao, Arin Guchhait, Dipanwita Dutta Chowdhury, Sushweta Mahalanobish, Tania Sarkar, Shatadal Ghosh, Debabrata Mandal, Sukanya Saha, Sayantani Chowdhury, Shibjyoti Debnath, Sarmistha Banerjee, Tapasree Basu Mallik, Sumit Ghosh, Sayanta Dutta, Apoorva Bhattacharya, Shruti Banerjee, Payel Das, Dia Roy, Subhanki Dhar, Tapasi Manna, Mousumi Kundu, Shabina Parveen, Supriya Chakraborty, Abhijit Das, Vivek Mandal, Nikhil B. Ghate, Sudip Bhattacharya, Soumyadip Paul, Bidisha Paul Chawdhury, Shahana Mitra, Bhawna Pandey, Barun Mahata, Manas Jana, Tamashree Ghosh, Dipankar Chawdhury, Suvranil Ghosh, Prasanta Saini, Amrita Bhattacharjee, Kahkashan Rashid, Naibedya Datta, Tarun Mahata, Aditya Singha Roy, Abhisek Sarkar, Devendranath Tewari, Aparajita Das, Apratim Dutta, Poulami Sarkar

Staff members: Mr. Probal Gupta, Mr. Uttam Kr Ghosh, Mr. Arindam Basu, Mr. Debasish Majumder, Ms. Nilanjana Bhattacharya, Ms. Sanghamitra Das, Mr. Sourav Samanta, Mr. Kalyan Das, Mr. Amartya Sen, Mr. Ranjit Das, Mr. Sankar Prasad Bari, Mr. Purnendu Manna, Mr. Bijoy Munsi.

Division of Plant Biology

Faculty: Dr. Samir Ranjan Sikdar (Sr. Professor & Head), Dr. Swati Gupta Bhattacharya (Sr. Professor), Dr. Debabrata Basu (Professor), Dr. Gaurab Gangopadhyay (Associate Professor), Dr. Shubho Chowdhuri (Associate Professor), Dr. PallobKundu (Associate Professor), Dr. Anupama Ghosh (Inspire faculty up to 30.06.2016 and Assistant Professor from 01.07.2016). 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).

Staff members: Dr. Chaitali Roy, Mr. Chanchal Chakraborty, Mr. Jadab Kr. Ghosh, Mrs. Kaberi Ghosh, Mr. Ashim Kumar Nath, Mr. Binoy Krishna Modak, Mr. Jayasish Ghosh, Mr. SubalBasak, Mr. Bipul Kumar Nag, Mr. Arup Kumar Dey, Mr. NadiramKayal, Mr. Birendra Kumar Bari, Mr. Sanjib Das, Mr. Tapas Chakraborty, Mr. KisunTuri, Mr. Siddhartha Roy, Mrs. Sarama Pradhan, Mrs. Moumita Mondal.

Research Associate and Scholars: Dr. Avishek Dey, Dr. Pijush Mullick, Dr. Mrinmoy Majumder, Ms. Monia Chatterjee, Mr. Ayan Das, Ms. Senjuti Sen, Mr. Joydeep Chakraborty, Ms. Jayanti Joddar, Mr. Sourav Bose, Ms. Papri Basak, Ms. Anju Patel, Mr. Dipan Roy, Ms. Payel Bhattacharya, Ms. Sayani Dey, Mr. Amit Paul, Ms. Amrita Mukherjee Ganguly, Ms. Deepti Sarkar, Ms. Sefa Parveen, Ms. Poulami Sarkar, Ms. PayelGanguly, Ms. Adrita Roy, Ms. Banani Mondal, Ms. Sanghamitra Adak, Mr. Sayantan Ghosh, Ms. Shruti Chattaraj, Mr. Rohit Das, Ms. Aishee De, Mr. Rahul Dutta, Ms. Rwitie Mallik, Mr. Dibya Mukherjee, Ms. Pratiti Dasgupta, Ms. Shreya Chowdhury, Mr. Amartya Ghosh, Ms. Udita Acharya, Mr. Subhasish Mukherjee, Ms. Surbhi Shriti, Ms. Karishma Chanani, Mr. Soham Mukhopadhyay, Ms. Jinia Chakraborty, Ms. Shrabani Basak, Ms. Meghma Bera, Dr. Sambit Datta, Mr. Milan Kumar Samanta, Dr. SoumitraMaiti, Dr. Subhobrata Ghosh, Ms. Niti Yashvardini, Mrs.Marufa Sultana, Md. S.U. Riyaz, Mr. Bodhisattwa Saha, Mr. Vivek Arora, Ms. Debarati Dey, Mrs. Sayantini Sihi, Ms. Sangita Roy, Mr. Arup Nayak, Ms. Nandini Ghosh, Mr. Gourab Sircar, Mr. Tathagata Nath, Ms. Koyel Sengupta, Ms. Bijoya Karmakar, Ms. Moumita Bhowmik, Mr. Debabrata Datta, Mrs. Moumita Biswas Sarkar, Mr. Subham Bhakta, Mr. Sukhendu Maity,

Environmental Science Section

Faculty: Prof. Sibaji Raha, Chairman; Dr Abhijit Chatterjee, Assistant Professor and Dr Sanat Kumar Das, Assistant Professor and Ramanujan Fellow.

Staff Members: Dr Anandamay Adak, Mrs Ishani Chaudhury, Ms Debolina Seal, Mr Saral Chandra Das.

Students/RA/Project Assistant : Dr. Debajyoti Roy, Research Associate, Dr Chirantan Sarkar, Research Associate Mr Arindam Roy (SRF), Mr Abhinandan Ghosh, SRF, Miss Tanushree Mukherjee, Project Assistant (Ramanujan Fellowship)

Falta Experimental Farm

Faculty: Dr. S.R. Sikdar (Division of Plant Biology) Sr. Professor & Coordinator Rural Biotechnology Programme.

Staff Members: Shri Sobhan Roy Chowdhury (Senior Technical Assistant on contract), Shri Debarshi Porel and Shri Shuvankar Roy (both are Technicians on contract), Shri Amal Krishna Purkait, Shri Santanu Haldar, Shri Sourav Mondal, Md. Sijarul Hoque, Shri Subal Kayal and Shri

Birsingh Mahato (all six are Master Trainers in the "Scheduled Tribe Specific Rural Biotechnology Programme"), Sk. Ansar Ali (Helper-G).

Microbiology Department

Faculty: Dr. Sujoy K. Dasgupta, *Professor & Chairman*, Dr. Tapan K. Dutta, *Professor*, Dr. Wriddhiman Ghosh, *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, Dr. Fatem Calcuttawala

Staff Members: Saifullah Gazi, Prabir Kumar Haldar, Debashis Sarkar, Dilip Bhattacharyya, Robin Paul, Narayan Patali.

Physics Department

Faculty: Dr. Sibaji Raha, Sr. Professor, Dr. Indrani Bose, Sr. Professor (CSIR Emeritus Scientist), Dr. Dipankar Home, Sr. Professor, Dr. Barun Kumar Chatterjee, Sr. Professor, Dr. Tripurari Prasad Sinha, Sr. Professor & Chairman, Dr. Swapan Kumar Saha, Sr. Professor, Dr. Sanjay Kumar Ghosh, Sr. Professor, Dr. Somshubhro Bandyopadhyay, Associate Professor, Dr. Dhruba Gupta, Associate Professor, Dr. Rajarshi Ray, Associate Professor, Dr. Supriya Das, Associate Professor, Dr. Achintya Singha, Associate Professor, Dr. Partha Sarathi Joarder, Associate Professor, Dr. Soumen Roy, Associate Professor, Dr. Siddharth Kr. Prasad, Asstt. Professor, Dr. Saikat Biswas, Asstt. Professor.

Students/RA/Project Assistant: Dr. Rupa Sarkar, Dr. Mandira Sinha, Dr. Anindita Banerjee, Dr. Subhrangshu Ghosh, Dr. Prasanna Kumar Mandal, Dr. Subikash Chowdhury, Ms. Sananda Raychaudhuri, Mr. Som Kanjilal, Mr. Pratapaditya Bej, Mr. Rathijit Biswas, Mr. Dipanjan Nag, 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, Mrs. Maitrayee Mukherjee, Mr. Mainak Pal, Mr. Soumya Jyoti Banerjee, Ms. Rajdeep Kaur Grewal, Mr. Saptarshi Sinha, Mr. Anup Pradhan Sakhya, Mr. Saswata Haldar, Md. Sariful Sheikh, Mr. Tara Shankar Bhattacharyya, Mr. Ram Awdhesh Kumar, Mr. Ritwik Maity, Mr. Pranay Biswas, Mr. Moumin Rudra, Mr. Tushar Kanti Bhaumik, Mr. Chayan Kumar Mitra, Mr. Sreyan Raha, Sk. Mustak Ali, Ms. Kabita Kundalia, Mr. Ranjan Sutradhar.

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.

IRHPA II: Dr. Sandhya Dey (Mandal), Dr. Atanu Maulik, Mr. Soumendra Singh, Mrs. Sumana Singh.

ALICE - II: Technical Assistant: Mr. Sanjoy Mukherjee.

M.Sc (Physical Science) Students: Ms. Shreya Roy, Mr. Pratik Ghosal, 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.

IRHPA – ASTROPHYSICS: Dr. Ajay Kumar Singh (IRHPA II, Research Scientist-C), Dr. Sandhya Dey (Mandal) (IRHA II, Research Scientist-C), Dr. Anindita Banerjee (SERB RA-II), Mr. Soumendra Singh (IRHPA 2, Research Scientist-C); Technical Assistants: Mrs. Sumana Singh, Mr. Bhaskar Roy, Mr. Bivek Gurung, Mr. Sabyasachi Majee, Ms. Debolina Seal.

Project Scientists/Technical Assistant: Dr. Partha Sarathy Ghosh, Professor (NASI Senior Scientist Fellow), Dr. Probir Roy, Professor (INSA Senior Scientist Fellow), Dr. Sidharth Kumar Prasad (Project ALICE II, RA-II), Mr. Sanjoy Mukherjee (Project ALICE II, Technical Assistant).

J. C. Bose Centre

(Publication and Museum)

Staff Members : Tarun Kumar Maji, Ishani Chatterjee, Chandra Kanta Sasmal

Library

Dr. Arun Kumar Chakraborty (Librarian : on lien, Dr. (Ms.) Banhisikha Chaudhuri (In-charge, Library), Ms. Ananya Raha, Ms. Sumita Dey (On lien).

Administrative Staff: Ms. Tanusri Bhattacharya, Mr. Gautam Mukherjee, Mr. Dipak Dutta, Mr. Mrityunjoy Jogsharma, Mr. Dinanath Das.

Workshop

Mr. Raju Chandra Paul ,Workshop Superintendent.

Main Campus: Mr. Panchanan Santra Technician Gr-1 retired on 28/02/17 and Mr. Panchu gopal karak retired on 31/03/2017.

Existing Staff members at the 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. Murari Mohan Shee Helper G retired on 30/11/2016

Existing Staff members at the Centenary Campus

Existing Staff Members:- Mr. Ashit Banerjee, Mr. Baidya Nath Murmu



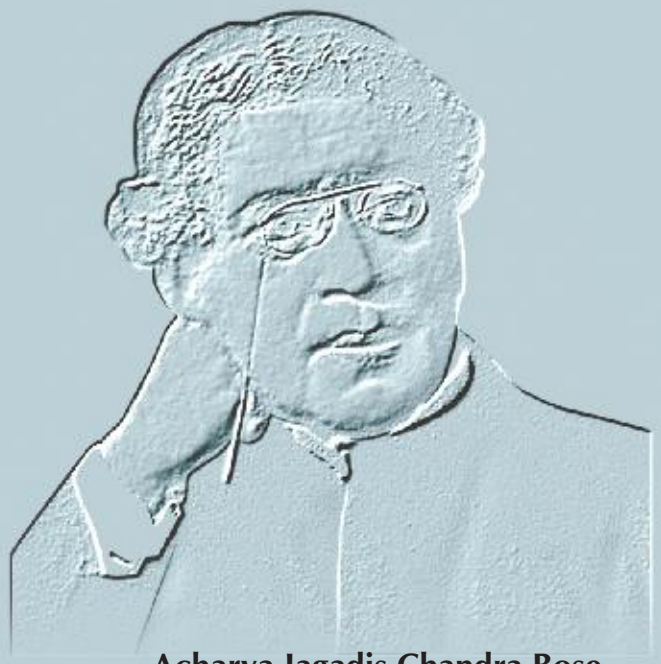

Press Meet: November 29, 2016

A Press Meet was held at the Lecture Hall, Bose Institute, Main Campus, Razabazar on November 29, 2016 for broadcasting the forthcoming objectives and scientific programmes of Bose Institute to mark its Centenary Year. The meet was presided over by Prof. Siddharta Roy, Director (Officiating). Other Faculties who opined included Prof. Sibaji Raha, Prof. S.R. Sikdar, Prof. Dipankar Home and Prof. Gautam Basu. Prof. Roy and Prof. Raha elaborated on the new areas of Research and their objectives in the field of Plant Science, Molecular Medicine, Astrophysics and so on, to be initiated by the Institute following the Centenary Year.

The meet was followed by a visit to the J.C. Bose Museum to highlight the attractions for the Centenary Year. This included display of twelve digitized Notebooks of Acharya Jagadis Chandra Bose containing his Experimental notes, College notes (1882-1884), Notes on instrument design, Visitors' Book (1917 onwards), Donation Book (1920 onwards), etc. The user friendly Touch Screen Kiosk on J.C. Bose and the Museum was a fascinating object of coverage by Media.

100th Foundation Day Celebrated

The 100th Foundation Day of Bose Institute was celebrated on November 30, 2016. **Professor Raghavendra Gadagkar,** Center for Ecological Sciences and Center for Contemporary Studies, Indian Institute of Science, Bangalore and President, Indian National Science Academy, Delhi graced the occasion as the Guest of Honour and delivered the 78th Acharya Jagadis Chandra Memorial Lecture on **Social Regulation of Reproduction in a Tropical Insect Society. Professor P. Balaram**, Molecular Biophysics Unit,Indian Institute of Science, Bangalore, presided over the programme. Prof. Siddhartha Roy, Director (Officiating), Bose Institute, delivered the Welcome Address and presented the Institute Report. Sir Nilratan Sirkar Prize 2016 was awarded to Ms. Shahana Mitra, (Under Dr. Atin K. Mandal) Division of Molecular Medicine. Prof. B. B. Biswas Outstanding Student Award 2016 were presented to Ms. Senjuti Sen, (Under Prof. Sampa Das) Division of Plant Biology and Mr Soumitra Polley (Under Dr. Subrata Sau) Biochemistry Department.



Acharya Jagadis Chandra Bose

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