BOSE INSTITUTE

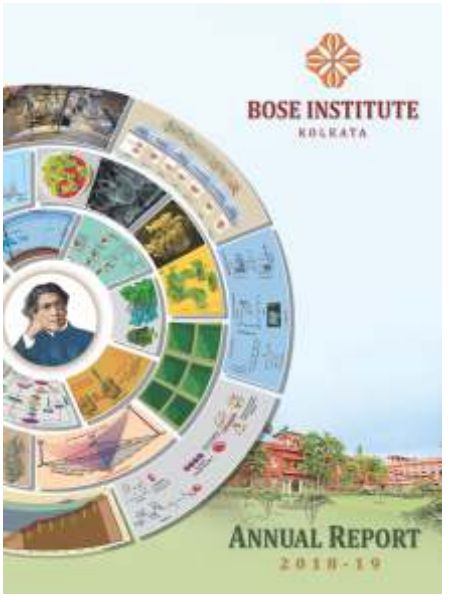
KOLKATA

ANNUAL REPORT

2018-19

Celebration of 102nd Foundation Day

The 102nd Foundation Day of Bose Institute was celebrated on November 30, 2018. **Prof. T. V. Ramakrishnan, FRS,** DST Year of Science Chair Professor, Distinguished Associate, IISc, Bangalore, and Emeritus Professor, BHU, Varanasi delivered the **80th Acharya J.C. Bose Memorial Lecture** on **"Acharya Sir Jagadish Chandra Bose: Harbinger of Science in Today's India."** Prof. Sujoy Kumar Das Gupta, Director (Officiating), Bose Institute, delivered the Welcome Address and presented the Institute Report. Prof. Indrani Bose, CSIR-Emeritus Professor presided over programme. Sir Nilratan Sirkar Prize 2018 was awarded to Ms. Pallabi Sengupta, Department of Biophysics. Prof. B. B. Biswas Outstanding Student Award 2018 were presented to Ms. Nabanita Saha, Department of Biochemistry and Ms. Jesmita Dhar, Division of Bioinformatics. Prof. Shyamadas Chatterjee Outstanding Student Award (in the area of Physical and Environmental Science) awarded to Ms. Satamita Deb, Department of Microbiology.



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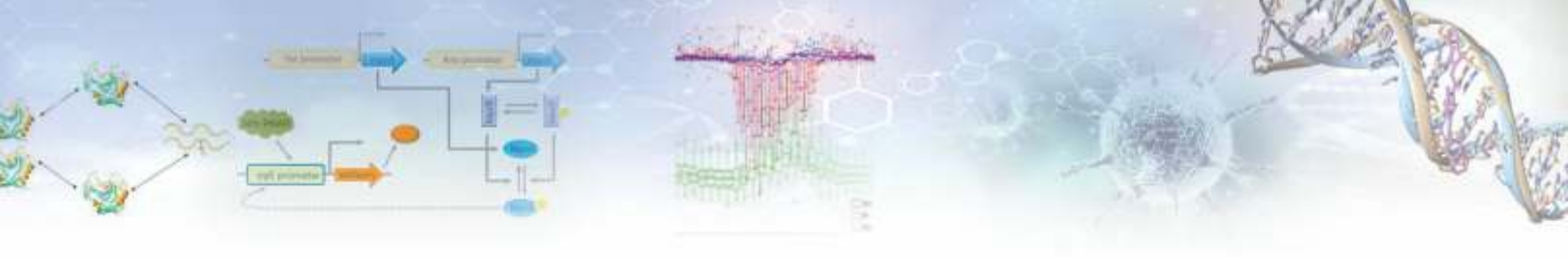

Edited by the members of
J. C. Bose Museum and Publication unit

Gautam Basu	(Chairman)
Gaurab Gangopadhyay	(Member)
Somsubhro Bandopadhyay	(Member)
Achintya Singha	(Member)
Tarun Kr. Maji	(Member)
Ishani Chatterjee	(Convener)

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cgpl2016@gmail.com

Contents

International Day of Yoga

International Day of Yoga was observed on June 21, 2018 at Madhyamgram Experimental Farm.

IISF – Outreach Programme at Bose Institute

Bose Institute organized an Outreach Programme to celebrate India International Science Festival (IISF)-2018, in association with Vivekananda Vijnan Mission, West Bengal Chapter of Vijnana Bharati, at the Main Campus of the Institute on September 28, 2018. Bose Institute also organized this programme at the Darjeeling Campus, on the same day.

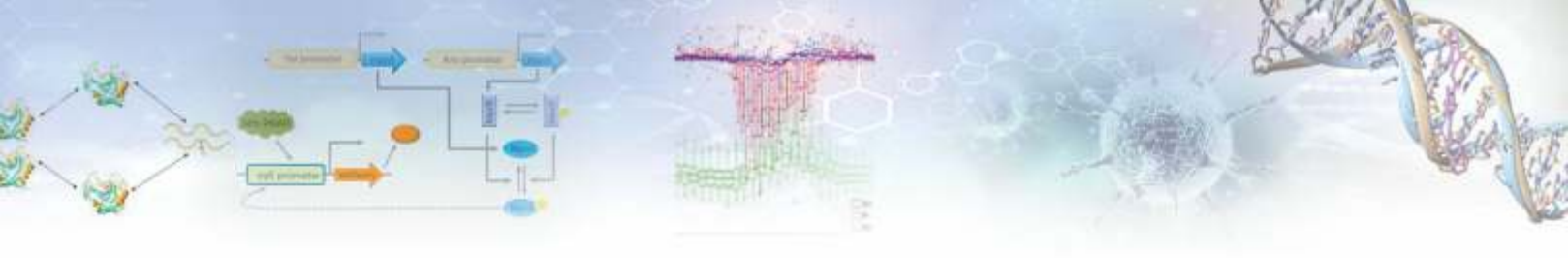
India International Science Festival (IISF-2018) at Lucknow

Bose Institute participated in the Mega Science, Technology & Industry Expo at the India International Science Festival (IISF) 2018 during October 5 – 8, 2018 at Lucknow. Prof. Ashutosh Sharma, Secretary to the Govt. of India, Ministry of Science & Technology, visited the stall of Bose Institute

From the Director's Desk

It gives me immense pleasure to present the Annual Report of Bose Institute for the year 2018-19 before you. We are passing through the time when higher education is undergoing rapid and dramatic transformation. We live in an era when knowledge is growing in importance in addressing the world's most pressing problems, when technology promises both wondrous possibilities and profound dislocations, when global forces increasingly shape our lives and work, when traditional intellectual fields are shifting and converging, and when public expectations and demands of higher education are intensifying. Bose Institute, founded by none other than Acharya J.C. Bose, the doyen of Modern Indian Science and made outstanding contributions to Science throughout its existence. Further, the objective of the iconic founder of the Institute was to develop and disseminate knowledge freely for the benefit of the mankind. Keeping his noble objective in view, the Institute carried out its research work for the last 100 years following the trail blazed by the great legend. The manifold R&D activities of the Institute not only cover fundamental and applied contributions to the repository of scientific knowledge, but also has been in the forefront of establishing many interdisciplinary areas, such as, Bioinformatics/Computational Biology, Biophysics, High-altitude laboratories for physical and life sciences. Here it is pertinent to mention that Acharya J. C. Bose, the pioneer of interdisciplinary research, set the foundation of Bose Institute and being a renowned Physicist, he was the first to venture into the world of Biology with instruments capable of precision measurements. He may have been the first biophysicist and interdisciplinary scientist to use physical tools to explore life. At present, apart from cutting-edge scientific research in several frontier areas of Biological and Physical Sciences, including actively participating in International Collaborative Mega Experimental Projects, Bose Institute, true to the exhortation of its founder, has also been actively developing social outreach programmes through Rural Biotechnology Programmes, and educational upliftment programmes for school children from North-East India.

During the year 2018-19, Bose Institute had published 236 numbers of full length peer reviewed research papers in referred journals and 20 Books. The Institute had produced 39 Ph.D. students and trained 154 research manpower (other than Ph.Ds) who are working in renowned Institutes all over the globe. Our Institute has also brought a considerable number of funded projects from National and International agencies and Industries.



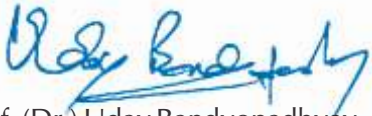
It is praiseworthy to mention here some of the important global and national collaborations with Bose Institute viz. *Indo-UK Water Quality Research Project (WQRP): The development and implementation of sensors and treatment technologies for freshwater systems in India (Newton-Bhaba Fund); Indo-Swedish Collaborative Programme: Antimicrobial peptides against crop disease; ALICE Collaboration: Study of hadronic as well as heavy ion collisions at ultra-relativistic energy at the LHC, CERN, Switzerland*; *CBM Collaboration: study of nuclear matter at very high density and moderate temperature at FAIR, Germany; DBT-NOW: Unravelling the role of PLC in plant drought and heat stress tolerance: Exploring the potential of PI metabolism to improve crop yield; Hydrogenogenic carbon monoxide conversion under mesophilic condition using anaerobic granular sludge biomass for biodesulpherization with IIT Guwahati, Assam; Multi-Dimensional Research to Enable Systems Medicine: Acceleration using a Cluster Approach with NIBMG, Kalyani, IISER Kolkata, TMC, Kolkata, ISI, Kolkata, IICB, Kolkata; Solid tumor targeting using homing peptides and plasmonic photothermal technique with CSIR-CSIO, CSIR-IIIM, IIT Ropar, AIIMS, Delhi; National Carbonaceous Aerosols Programme (NCAP) WGIII: Carbonaceous Aerosols Emmissions, Source appointment and Climate effects with IIT Bombay and 16 others; Fabrication of Infrared Photo-detector based on 2D systems and Tuning the Detection Windows by coupling with Nanostructures with Jadavpur University* etc.

Among outreach activities of the Institute, I may mention a few like *Participation in the Mega Science, Technology and Industry Expo at the India International Science Festival 2018 at Lucknow;* conference entitled *"Rural biotechnology programme and economic development of scheduled tribe people: present status and future"* was organized.

The students and academic staff members have been conferred with numerous awards and accolades. A few of them are: *Prof. Tanya Das, Division of Molecular Medicine, was conferred the P. B. Rama Rao Memorial Award at the 87th AGM of the Society of Biochemists, India; Dr. Zhumur Ghosh received the NASI-SCOPUS Women In Science Excellence Award* etc.

Bose Institute hosted lectures by eminent scientists viz. eminent physicist Prof. T. V. Ramakrishnan, FRS, delivered *80th Acharya Jagadis Chandra Bose Memorial Lecture* on the 102nd Foundation Day celebration of Bose Institute on 30-11-2018; *Prof. Somak Raychaudhury, Director, Inter-University Centre for Astronomy and Astrophysics, Pune,* delivered *D. M. Bose Memorial Lecture* on the 134th Birth Day celebration of Professor Debendra Mohan Bose on 26-11-2018 etc.

I am thankful to our Council Members especially to our Hon'ble Chairman for valuable advice, guidance and vision from time to time ensuring holistic development of the Institute. I feel privileged to express my heart-felt gratitude to our funding agency, the Department of Science and Technology, Government of India, for their sustainably uninterrupted support enabling us to fulfill our research needs as well as to make significant contributions to the country by striving towards excellence and by developing highly competent and trained scientific manpower.



Prof. (Dr.) Uday Bandyopadhyay
Director
Bose Institute, Kolkata

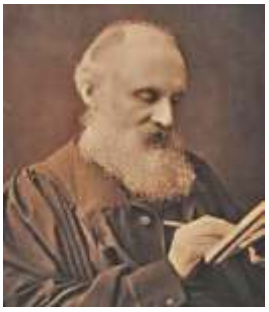
Remarks By Eminent Personalities

"In the pursuit of my investigations I was unconsciously led into the border region of physics and physiology and was amazed to find boundary lines vanishing and points of contact emerge between the realms of the Living and Non- living"

(Acharya J.C. Bose in *'The Voice of Life' by November 30, 1917, p.p.3-4:* J.C. Bose Museum Archives)

"Here in Paris have assembled the great of every land, each to proclaim the glory of his country. Savants will be acclaimed here; and its reverberation will glorify their countries. Among these peerless men gathered from all parts of the world, where is thy representative, O thou the country of my birth? Out of this vast assembly a young men stood for thee, one of thy heroic sons, whose words have electrified the audience, and will thrill all his countrymen. Blessed be this heroic son; and blessed be his devoted and peerless helpmate who stands by him always"

(Swami Vivekananda, in a letter from the Paris International Congress of the Physicists in 1900, where Acharya. J.C. Bose read a paper on "*Response of Inorganic and Living Matter*": *The Calcutta Municipal Gazette, 1st December, 1928* pg.179)

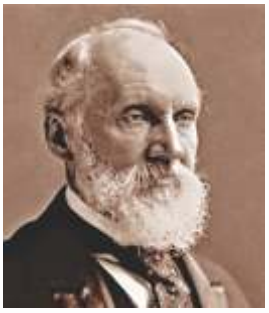


"…I have seen enough to fill me literally with wonder and admiration, and to allow me to ask you to accept my congratulations for so much success in the difficult and novel experimental problems which you have attacked"…

(*Excerpt from a letter by Lord Kelvin to Acharya J.C. Bose, 14.04.1896:* J.C. Bose Museum Archives)

"It seems that you have revolutionized in some respects, and very much extended in others our knowledge of the response of plants to stimulus."

(Prof. Sydney H. Vines, 1902*: The Calcutta Municipal Gazette, 1st December, 1928, pg.159)*



"I believe it will be conducive to the credit of India and to Scientific Education in Calcutta, if a well-equipped Physical Laboratory is added to the resources of the University of Calcutta in connection with the Professorship held by Dr. Bose."

(Excerpt from letter by Lord Kelvin to the Secretary of State, 23rd October, 1906 Source: Archives of University of Strathclyde, Glasgow*)*

"I was much impressed on Saturday last by the most ingenious and novel self-recording instruments, whereby you are able to make plants automatically record their response to electric and other stimulation and their own movements when no outside stimulus affects them. The means of physiological investigation thereby afforded is likely to prove of importance....."

(Excerpt from letter by Sir William Crookes, to Acharya J.C. Bose dated 27th May, 1914: J.C. Bose Museum Archives*)*

"The Bose Institute is of the greatest value for two reasons, firstly, because it is the laboratory where our great scientist carries on his work; secondly, because it is where the master is able to hand his scientific knowledge to others: the factory, in short, in which the scientists of the future are being made....."

(Lord Lytton, *in a speech given on the 17th October 1925:* The Calcutta Municipal Gazette, December 1, 1928, pg.163)

"I am among the fortunate who were able to sit at the feet of the great master for their first lessons in modern Physics; and I still recollect the thrill of intense delight which we all felt, when he modestly talked about his striking discoveries on Electric Waves in his class."

(Excerpt from Acharya Jagadis Chandra Bose Memorial Address by *Prof. Satyendra Nath Bose in 1954:* Science and Society- Reflections, pg.150*)*

"Anyone who came to know him was impressed not only by his scientific imagination and inventive skill but also by his pride and patriotism. In him was a harmonious blend of science, art and religion. The Institute, which he founded, is an illustration of his integrated outlook. It is not merely a laboratory but a temple. The working table is an altar."

(*Excerpt from Acharya Jagadis Chandra Bose Memorial Address by Dr. Sarvapalli Radhakrishnan in 1958:* Science and Society- Reflections, pg.195)

"J.C. Bose was at least 60 years ahead of his time" and "in fact he had anticipated the existence of p-type and n-type semiconductors"

(*Sir Neville F. Mott remarked in 1977*: *The Work of Jagadis Chandra Bose: 100 Years of Millimeter-Wave Research* by D.T. Emerson: Transactions on Microwave Theory and Techniques, Vol.45, No.12, December 1997, pg.2268)

"I was very much impressed by the ingenuity of Professor Bose, specially his very informative experimental set-ups for biological and physical measurements. He was really very much ahead of his time. I also like very much his interdisciplinary approach so essential for mastering our future."

(Prof. Richard R. Ernst, Nobel Laureate in Chemistry: Visitor Book of J.C. Bose Museum, 25.09.1999)

"This is a wonderful experience for me since Sir J.C. Bose actually performed the first wireless experiment before that of my grandfather Guglielmo Marconi. Many thanks for your hospitality. I appreciate the honour."

(Prof. Francesco Paresce Marconi, grandson of Italian scientist G. Marconi: Visitor Book of J.C. Bose Museum, 30.11. 2006*)*

"Thank you for your warm hospitality and for the most interesting introduction into the work of this world renown Institute."

(*Prof. Harald zur Hausen, Noble Laureate in Physiology & Medicine::* Visitor Book of J.C. Bose Museum, 03.12.2009)

BOSE INSTITUTE

Established: 30th November, 1917

Introduction

Bose Institute was founded by Acharya Jagadis Chandra Bose in 1917 for the advancement of science and dissemination of knowledge. In his foundation day speech the Acharya declared that **"I dedicate today this Institute – not merely a laboratory but a temple".** Thus, our Institute is also known as the *Vigyan Mandir* or Temple of Science.

In the beginning, there were only three major departments, namely Physics, Chemistry and Botany. All the three continue to exist, but with the passage of time many new departments, divisions and centers have evolved. The pursuit of science is a dynamic process and therefore as and when new disciplines emerged, changes had to be made in the departmental structure. At present we have four departments: Physics, Chemistry, Microbiology and Biophysics. In addition, there are two divisions: Plant Biology and Molecular Medicine. Also we have three centers named as Center for Astroparticle Physics, Acharya J. C Bose Biotechnology Innovation Center (MEF) and finally the Bioinformatics Center (now Division of Bioinformatics w.e.f. November 2018).

The Institute provides financial and infrastructural support to its faculty members in various forms. The Central Instruments Facility harbors all the major equipments necessary for performing research in the areas of chemical, physical and biological Sciences. This facility is used not only by the in house scientists, but also by scientists and research scholars from several neighboring institutes and universities. The other facilities that are available at Bose Institute are: a) the Centre for Translational Animal Research facility (CTAR), Madhyamgram campus, b) a state-of-the-art Workshop capable of designing and fabricating instruments for biological as well as physical research, c) a well stocked and fully digitized Library having a huge collection of old and new journals and d) the J.C. Bose museum which houses the original as well as replica of several research instruments that our founder designed in his life time.

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

Teaching and Training programs

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

The eminence of Bose Institute's scientific research, spanning a wide range of disciplines, is evident from the large number of research publications in most competitive peer reviewed international and national journals, and from the recognition received by the scientists in the form of S.S. Bhatnagar Prize, INSA young scientist award, fellowship of the National Science Academies, fellowship of the Third World Academy of Science, Nehru Fellowship, K.S. Krishnan Fellowship, Rockefeller Foundation fellowship and Homi Bhabha fellowship.

The Institute has, over the years, provided yeoman service in manpower development, having trained a large number of Ph.D. students, many of whom are now reputed experts in their fields in India and abroad; on an average, 30-40 scholars are awarded Ph.D. degree every year. Every year, a number of our scientists and research scholars participate in numerous academic activities (seminars, conferences, workshops) in India and abroad as invited speakers, chairpersons and resource persons. A large number of extramural research projects, with support from various government agencies as well as international funding agencies, are carried out at Bose Institute.

Research programs

Bose Institute pursues research for enhancement of fundamental knowledge-base and strives to develop solutions to national problems in the areas of healthcare, food security, environmental pollution and climate change. The areas of research broadly cover Plant Sciences, Structural Biology, Molecular Biology, Biomedical Sciences, Biotechnology, Quantum Mechanics, High Energy Physics, Astrophysics and Condensed Matter Physics.

The efforts of institute's researchers have yielded the following results in the year 2018-2019:

- Dual regulations at transcriptional and processing steps determine a microRNA level in tomato tissues during stress
- Unveiling of the immune landscape of tumor micro-environment towards understanding the failure of immunotherapy and development of the next generation immunotherapy
- Establishment of cancer as a 'stem cell disease' and repurposing FDA-approved drugs for sensitizing highly resistant cancer stem cells
- New strategy for nanoparticle-mediated drug & gene delivery developed
- Design and synthesis of glycoconjugates for development of antibacterial vaccine candidates

- A novel epigenetic mechanism underlying the transcriptional regulation of the Gm2-synthase gene in cancer was identified
- Identification of an oxidative-stress response factor that drives the pioneering signal for cellular inflammation
- Deciphering how *Mycobacterium tuberculosis* regulates host innate immunity using transcriptional and post-transcriptional mechanisms
- A recombinant reporter assay in *E. coli* has been developed to identify the interaction of RNA polymerase or transcription factors with promoters of *Mycobacterium tuberculosis*.
- Understanding how anthropogenic influence shapes the distribution and dissemination of antibiotic resistance in natural environment
- Structural determinants that preserve function and stability of a global staphylococcal virulence regulator, SarA, have been identified
- Pilot study on human plasma proteomics of asthmatics identifies Apo E and IL-33 as asthma markers
- A chronic asthma mouse model has been developed
- A systems approach to decipher shortest paths of gene interaction within different cancer systems for better understanding of disease progression has been developed
- A novel role of corn smut fungi secreted ribonucleases as effector proteins has been uncovered
- Epigenetic marks responsible for change in chromatin structure associated with transcriptional regulation of stress responsive genes in rice has been identified
- Novel role of plant nuclear architectural proteins in pollen development was documented
- Protein folding studies were performed using dark state exchanged saturation transfer NMR techniques
- Nontoxic short peptides were designed that specifically target c-Myc oncogene to repress its transcriptional / translational expression in breast cancer
- Local epigenetic landscape of the promoter element of an oncogenic transcription factor is instrumental in maintaining its elevated status has been established
- First Indian experiment entitled ` *Search for higher excited states of* ^{8}*Be* to study the cosmological* ^{7}*Li problem'* at CERN-HIE-ISOLDE, Geneva, Switzerland successfully carried out in November 2018
- Au -MoS2 shown to be an efficient molecule sensor and it is sensitive enough to detect free bilirubin in human serum even in the presence of crucial interferences
- Active detectors for Cosmic Ray measurements commissioned and running successfully at Darjeeling

- The first ever study on the trend of atmospheric aerosols and black carbon over eastern Himalaya has been conducted revealing decreasing trend associated with biomass burning over Indo-Gangetic plains
- Study of below cloud scavenging of aerosols of different size and pollution level by the rain of different physical properties over eastern Himalaya has been conducted for the first time
- Study of the physical and chemical properties of aerosol and rain over eastern Antarctica under 36th Indian scientific expedition to Antarctica
- A novel type of promoters identified in mycobacteriophage D29 that can positively and negatively regulate gene expression through the mutually exclusive binding of regulatory proteins
- Coupling of organic carbon sequestration and greater bioavailability intensify the carbon-sulfur cycle in the oxygen minimum zone sediments along the Arabian Sea coast of India

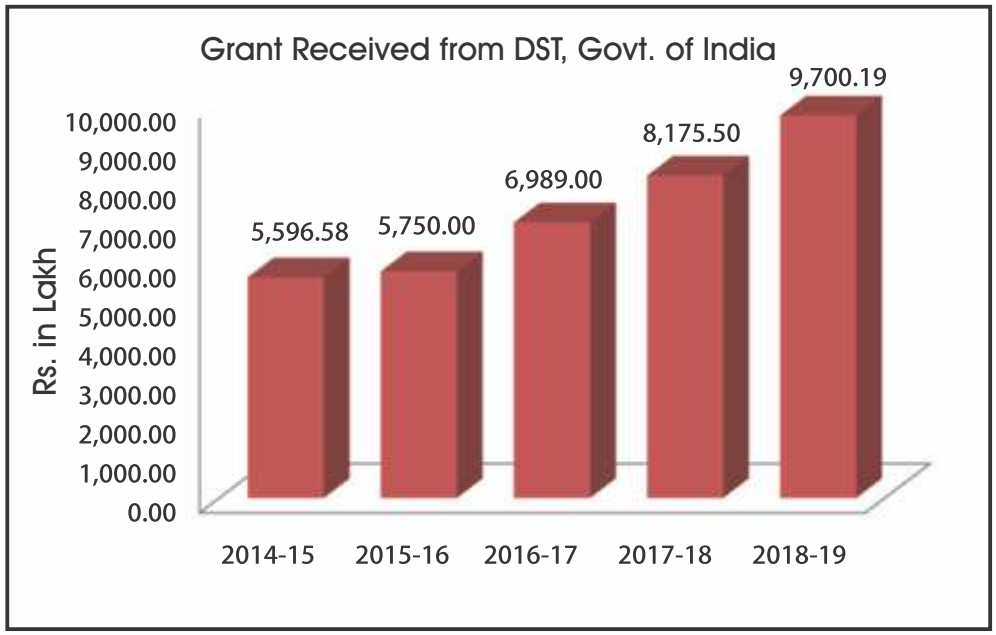
Important Global and National Collaborations

Indo-UK Water Quality Research Project (WQRP)- The development and implementation of sensors and treatment technologies for freshwater systems in India (Newton-Bhaba Fund)

Indo-Swedish Collaborative Programme- Antimicrobial peptides against crop disease

ALICE Collaboration- Study of hadronic as well as heavy ion collisions at ultra-relativistic energy at the LHC, CERN, Switzerland

CBM Collaboration- study of nuclear matter at very high density and moderate temperature at FAIR, Germany.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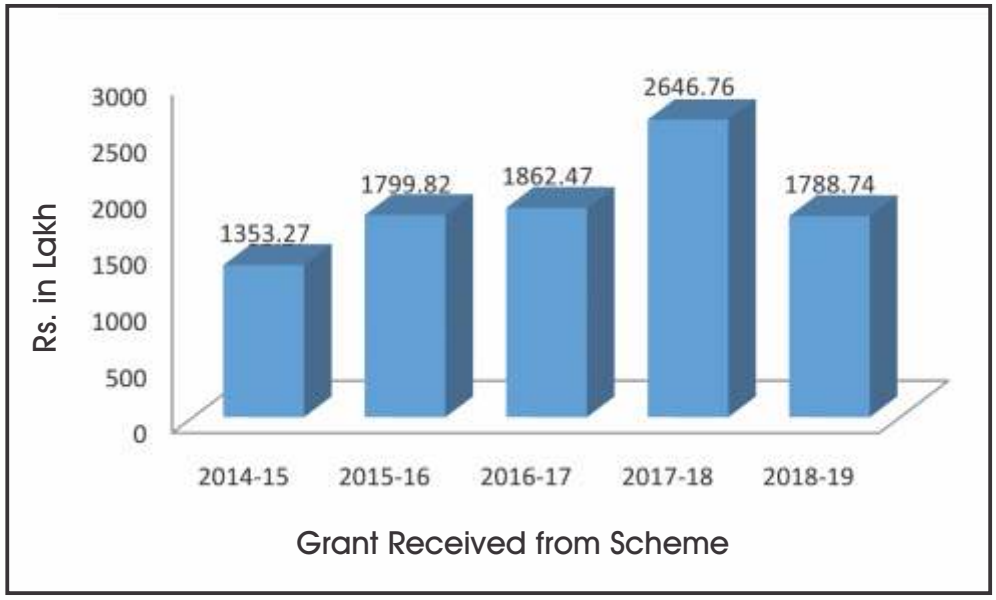
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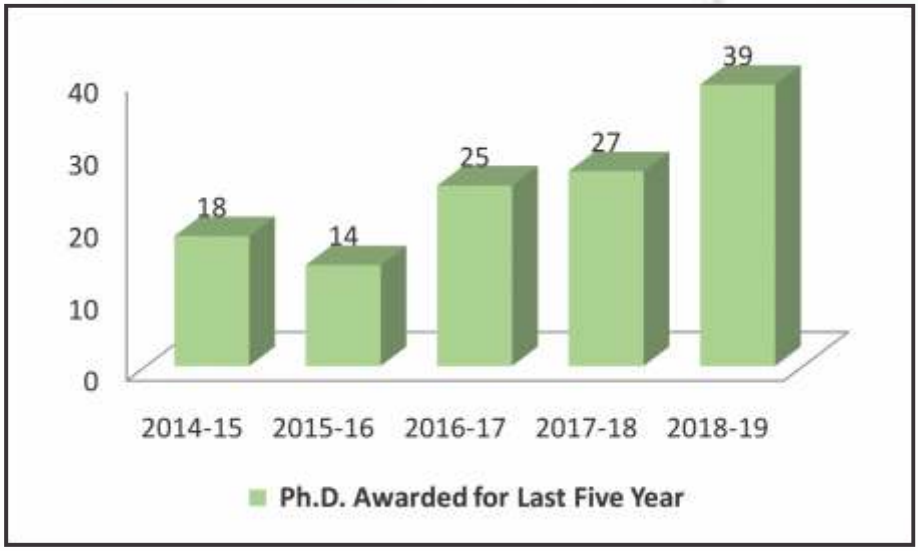
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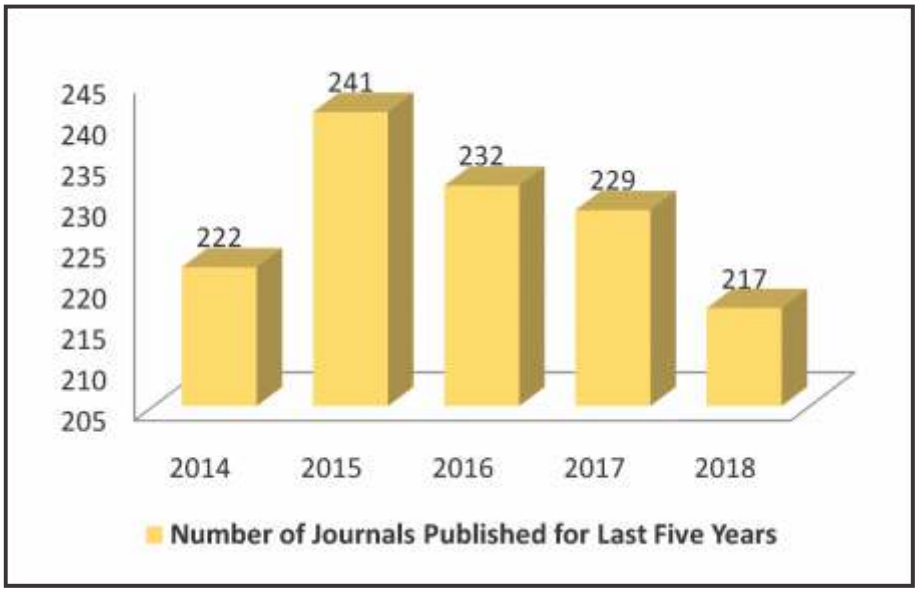
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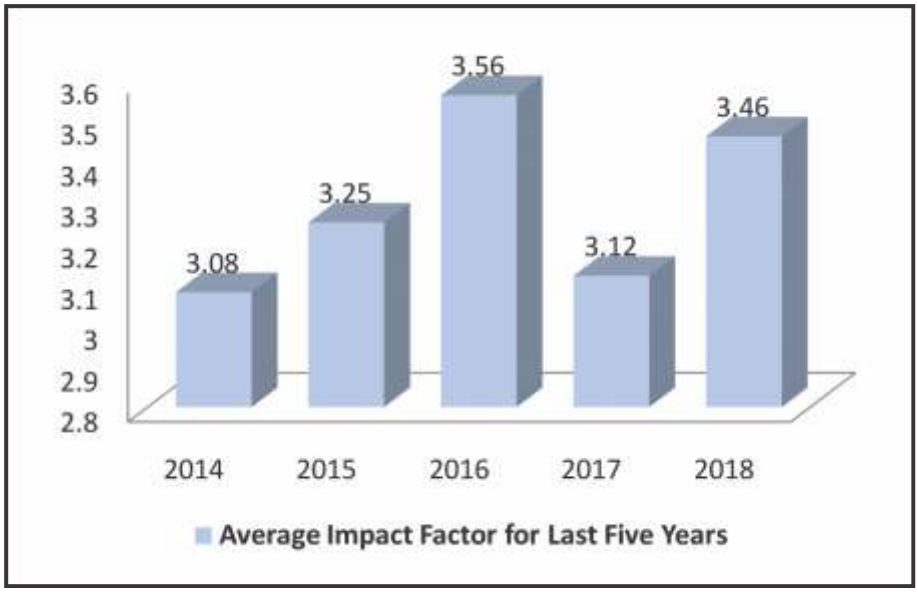
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2018
Average Impact Factor for Last Five Years

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.

Bose Institute Governing Body

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

Bose Institute Council

1. Prof. Gautam R. Desiraju, Chairman
   IISc, Bangalore
2. Prof. Dipankar Chatterji
   Honorary Professor, Molecular Biophysics Unit, IISc, Bangalore.
3. Prof. G. Balakrish Nair
   Distinguished Professor, RGCB Bio Innovation Center, Thiruvananthapuram, Kerala
4. Prof. Subodh R Shenoy
   Visiting Professor TIFR, Hyderabad
5. Prof. Basanta Kumar Nandi
   Dept. of Physics, IIT Mumbai.
6. Secretary, DST or His nominee
7. Financial Adviser, DST
8. The Chief Secretary, Govt. of WB or his nominee
9. The Director, Indian Association for the Cultivation of Science, Kolkata
10. The Director, S. N. Bose National Centre for Basic Sciences, Kolkata
11. The Director, Bose Institute
12. The Registrar, Bose Institute – Non-Member Secretary

Members of the Finance Committee

1. The Chairman, Bose Institute Council, Chairman.
2. Secretary, DST, Govt. of India or his nominee
3. Financial Advisor, DST, Govt. of India or his nominee
4. The Director, Bose Institute
5. The Registrar, Bose Institute - Secretary

Members of the Research Advisory Council (RAC)

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Department of Biochemistry, IISc, Bangalore

Prof. Prasanta K. Panigrahi, Member
Department of Physical Science, IISER, Kolkata

Prof. Arindam Ghosh, Member
Department of Physics, IISc, Bangalore

Dr. Ramesh V Sonti, Member
CSIR - Centre for Cellular & Molecular Biology, Hyderabad

Dr. Amit Sharma, Member
Protein Structure & Bioinformatics Research Group, ICGEB, New Delhi

Prof. Dipankar Nandi, Member
Department of Biochemistry, IISc, Bangalore

Prof. Ashwini Nangia, Member
Director, CSIR - NCL, Pune and University of Hyderabad

Prof. J. N. Moorthy, Member
Director, IISER, Thiruvananthapuram

Prof. Mahan Maharaj, Member, TIFR, Mumbai
Registrar, Secretary, Bose Institute, Kolkat

Administration

Prof. (Dr.) Uday Bandyopadhyay, Director (Joined on 03-04-2019)
Prof. Sujoy Kr. Das Gupta, Director (Officiating)
Mrs. Noreen Bhattacharjee, Acting Registrar & Deputy Registrar

Shri Subir Kr. Sen, Accounts Officer-I (Superannuated on 30-04-2018)
Smt. Rina Roy, Assistant Registrar-I
Shri Sougato Banerjee, Assistant Registrar-I
Shri Sisir Chakraborty, Assistant Registrar-I
Shri Achintya Mukherjee, Accounts Officer
Shri Vikash Kumar, Audit & Finance Officer
Shri Mantu Bhattacharya, Assistant Registrar
Shri Tarun Kumar Maji, Assistant Registrar (Publication)
Shri Vineet Kumar Tandon, Assistant Registrar
Shri Supriya Das, Technical Officer
Shri Kamal Sing, Accounts Officer (Cash)
Shri Debdas Nandi, Assistant Registrar
Shri Somnath Das, Assistant Registrar
Smt. Rubi Sarkar, Assistant Registrar
Shri Sudam Ch. Jana, Assistant Registrar
Shri Amitava Bhattacharyya, TO-A
Smt. Babli Marrick, Office Superintendent
Shri Satyaswaroop Behara, Office Superintendent
Smt. Ananya Malgope, Office Superintendent
Shri Nitin Sharma, Office Superintendent
Smt. Gopa Dasgupta, Office Superintendent
Smt. Rina Das, Office Superintendent
Shri Sanjoy Krishna Chaki, Office Superintendent
Shri Debasish Koley, Accountant
Shri Angshuman Bhowmik, Accountant
Shri Sukanta Chakraborty, Accountant
Smt. Sujata Roy, Accountant
Dr. Ishani Chatterjee, Curator
Shri Arjun Das, Sr. Technical Assistant
Shri Biplab Malakar, Upper Division Clerk-I
Shri Bipul Kr. Nag, Upper Division Clerk-I
Smt. Arpita Bose, Stenographer-I
Shri Animesh Jana, Stenographer-I
Shri Ratan Saha, Upper Division Clerk-I
Shri Shaubhik Ghosh, Upper Division Clerk-I
Shri Atanu Deb, Upper Division Clerk-I
Shri Sumanta Ghosh, Jr. Overseer-cum-Caretaker
Shri Tuhin Saha, Upper Division Clerk
Shri Mahendra Nath Shee, Technician Gr.-I
Shri Kanai Hazra, Technician Gr.-I
Shri Sanat Kumar Dhara, Technician Gr.-I
Shri Khairul B. Mollah, Upper Division Clerk-I
Shri Satyabrata Chatterjee, Helper-G (Superannuated on 31-12-2018)
Shri Jagabandhu Nayak, Helper-G (Superannuated on 31-01-2019)
Shri Munna Turi, Helper-G (Superannuated on 31-01-2019)
Shri Madhu Sudan Marrick, Helper-G
Sk. Md. Kalu, Helper-G
Shri Kali Charan Turi, Helper-G
Shri Prafulla Bhuiya, Helper-E
Shri Chandra Kanata Sasmal, Helper-D
Shri Duryodhan Nayak, Helper-D
Smt. Sarda Devi, Helper-D
Smt. Raj Kumar Balmiki, Helper-C
Shri Bablu Mondal, Upper Division Clerk
Shri Rajbrat Ram, Upper Division Clerk
Shri Hemanta Kr. Sahoo, Driver-cum-Mechanic
Shri Goutam Behera, Driver-cum-Mechanic
Shri Gourango Paramanick, Driver-cum-Mechanic

Department of Biochemistry

Introduction

The Department of Biochemistry, since its establishment in 1974, continues to address questions aimed at decoding the multifarious languages of life. Ongoing research areas include (i) determination of structure, function, and stability of the bacterial proteins involved in gene regulation, protein folding, and pathogenesis, (ii) understanding divergent molecular machinery for protein degradation and subcellular membrane organization in a non-traditional, pathogenic model organism, (iii) decoding the molecular basis of specificity and plasticity in protein-protein interactions regulating cellular networks and functions, (iv) deciphering biochemical basis of organismic interactions under stress conditions, with an emphasis on microbial communities, (v) determination of the antibacterial/anti-fibrillation activity of nanoparticles, (vi) decoding *Vibrio Cholerae* proteomics, (vii) understanding protein fibrillation and inhibition using PIMT and small molecules, (viii) deciphering weak interactions in proteins, and (ix) identification of structural motifs. Recent key achievements include identification of functional residues and multi-state folding mechanisms of virulence factors of *Staphylococcus aureus*; how expansion of protein families in a human parasite allows repurposing of




proteins to perform parasite-specific functions; functional correlation of anti-correlated conservation of a single tryptophan residue and dimerization in ubiquitin ring E3 ligase; demonstration that oligomeric plasticity in archaeal small heat shock protein is a key factor for in vitro protein protection and lipid stabilization; exhibition of antimicrobial effects of ZnO and gold nanoparticles on Vibrio cholerae.

Faculty

Dr. Subrata Sau, Professor and Chairman; Dr. Srimonti Sakar, Professor; Dr. Ajit Bikram Datta, Associate Professor; Dr. Abhrajyoti Ghosh, Assistant Professor.

Research Scientists

Dr. Pinakpani Chakrabarti, J.C. Bose Fellow; Dr. Tanaya Chatterjee, DST-(WOS-A): Dr. Swapan Kr. Jana, In J.C. Bose Fellowship - Dr. Pinakpani Chakrabarti: Dr. Shreyasi Dutta, Post doctoral Fellow: Dr. Chumki Bhattacharyya, UGC Post doctoral Fellow.

Staff Members

Mr. Subhash Chakraborty, Technical Officer – II; Mr. Asim Kumar Poddar, Technical Officer – I; Ms. Rama Chatterjee, Office Superintendent; Ms. Debarati Kanjilal, Office Superintendent; Mr. Atanu Pramanik, Senior Laboratory Assistant; Mr. Kissun Turi, Helper - G.

Students/RA/Project Assistant

Mr. Manish Sarkar, JRF, DST-Inspire Fellow; Mr. Arghya Bhowmick, JRF, CSIR Adhoc Fellow; Ms. Ankita Das, JRF, DST-Inspire Fellow; Ms. Nabanita Patra, JRF, CSIR Fellow; Ms. Priya Rai, JRF, UGC-Adhoc Fellow; Mr. Tushar Chakraborty, JRF, Institute Fellow–Integrated M.Sc.-Ph.D.; Mr. Kaustav Bhakta, JRF, Institute Fellow–Integrated M.Sc.-Ph.D.; Ms. Rupsa Roy, JRF, CSIR-Adhoc Fellow; Ms. Avishikta Chatterjee, JRF, DST Inspire Fellow; Ms. Pritha Mondal, JRF, CSIR-Adhoc Fellow; Mr. Pritam Naskar, SRF; Mr. Supriyo Bera, SRF; Ms. Shamila Sarwar, Project Assistant in J.C. Bose Fellowship - Dr. Pinakpani Chakrabarti; Ms. Ananya Jana, SRF, CSIR Fellow; Mr. Mousam Roy, UGC Adhoc Fellow; Mrs. Chandrima Bhattacharyya, DST Inspire Fellow; Mr. Sayantan Mukherjee, UGC Adhoc Fellow; Mr. Debabrata Sinha, UGC Adhoc Fellow; Mr. Sayandeep Gupta, CSIR Fellow; Mr. Soham Seal, Institute Fellow–Integrated M.Sc.-Ph.D.; Ms. Jesmita Dhar, Project Assistant in J.C. Bose Fellowship - Dr. Pinakpani Chakrabarti. Ms. Sayani Sarkar, Mr. Adaitya Prasad Behera, Chumi Bhattacharjee, UGC Past Doc. Fellow; Shankari Prasad Datta, INSPIRE Fellow; Nabanita Saha, UGC Fellow; Dr. Somi Patranasis, Former DBT-RA; Dhritimon Dey, Former WB-DBT Senior Project Assistant.

Ms. Nabanita Saha
Winner of Prof. B. B. Biswas
Outstanding Student Award 2018

DR. ABHRAJYOTI GHOSH
Assistant Professor

Name of the Participants

Chandrima Bhattacharyya, INSPIRE Fellow-*Adhoc*; Shayantan Mukherji, UGC-*Adhoc*; Mausam Roy, UGC-*Adhoc*, Sayandeep Gupta, CSIR-SRF *Adhoc*; Arghya Bhowmick, CSIR-*Adhoc*; Koustav Bhakta, Institute Fellow, Rupsa Roy, CSIR-*Adhoc*; Dr. Somi Patranabis, former DBT-RA; Dhritiman Dey, former WB-DBT Senior project assistant.

Background

My laboratory works on understanding the stress response in model organisms as well as microbial communities from different environmental niches. We use a variety of techniques starting with biochemistry, microbiology and genomics to unravel the molecular players important in adaptation and evolution of microorganisms under stress conditions.

Aims and Objectives

The broad focus of our research group is to understand the microbial structure, function and adaptation in environment. With this broad idea we defined the current objectives as

a) To understand how human intervention alters microbial structure and function in natural environment.
b) Antibiotic resistome analysis in natural environment.
c) Stress-adaptation of rhizobacteria and the role of anthropic factors.
d) Understanding stress-response in archaea: insights from ancient molecular motors.

Work Achieved

a) Understanding oligomeric plasticity of *S. acidocaldarius* Hsp20 and its contribution to *in vitro* protein protection and lipid stabilization.

b) Understanding the role of human activities in shaping the distribution of antibiotic resistant bacteria (ARB) and antibiotic resistant genes (ARGs) in natural environment.

Future Research Plans

a) Understanding the cross-talk between microbes in environment and their hosts under stress conditions.

b) Role of anthropogenic factors in co-selection of antibiotic resistance in natural environment and experimental evolution studies on the effect of antimicrobials in natural environment.

c) Investigation of the interactions between heat shock proteins in archaea in maintenance of the cellular protein homeostasis.

Students Awarded Ph.D.

Anish Bhattacharyya (CU, 2018 as joint-supervisor) Astudy on culture dependent and independent intervention of bacterial and archaeal communities in Sundarbans, the world heritage site.

Publication(s)

a) Bhattacharyya A, Haldar A, Bhattacharyya M, Ghosh A (2019) Anthropogenic influence shapes the distribution of antibiotic resistant bacteria (ARB) in the sediment of Sundarban estuary in India. *Sci Total Environ*. 647: 1626-1639 doi: 10.1016/j.scitotenv.2018.08.038

b) Roy M, Gupta S, Patranabis S, Ghosh A (2018) The oligomeric plasticity of Hsp20 of Sulfolobus acidocaldarius protects environment-induced protein aggregation and membrane destabilization. *BBA-Biomembranes* 1860(12):2549-2565. (https://doi.org/10.1016/j.bbamem. 2018.09.005)

c) Roy D, Pramanik A, Banerjee S, Ghosh A, Chattopadhyay D, Bhattacharyya M (2018) Spatio-temporal variability and source identification for metal contamination in the river sediment of Indian Sundarbans, a world heritage site. *Environmental Science and Pollution Research* 25(31):31326-31345. (DOI:10.1007/s11356-018-3092-x)

Extramural Funding

a) Response of B. aryabhattai AB211 to maize root exudates: insights from transcriptome analysis; SERB, Govt of India, Start date: 26th February 2019.

b) Understanding protein translocation under extreme conditions; DST-Ramanujan fellowship; Termination date: 31st December 2018.

c) Investigation of the archaeal diversity and activity in Sundarbans mangrove sediment, India; CSIR, Govt. of India; Termination date: 31st December 2018.

d) Assessment of plant growth promoting bacteria in the mangrove rhizosphere and evolution of the plant growth promotion activity on rice; WB-DBT, Govt. of West Bengal, India; Termination date: 31st March 2019.

Awards / Honours / Memberships

- Recipient of EMBO travel grant to attend EMBO workshop on "Molecular biology of archaea: From mechanisms to ecology" at the University of Vienna, Austria, 2018.

Conference(s) / Workshop(s) : One (International):

- EMBO workshop on "Molecular biology of archaea: From mechanisms to ecology" at the University of Vienna, Austria, 2018.

DR. AJIT BIKRAM DATTA
Associate Professor

Name of the Participants

Mr. Pritam Naskar, Ms. Sayani Sarkar, Mr. Adaitya Prasad Behera.

Collaborator

Prof. M. Dasgupta, Dept. of Biochemistry, University of Calcutta, Kolkata.

Background

Post-translational modification of proteins such as ubiquitination and phosphorylation regulate almost all sub-cellular processes in eukaryotes. In fact, kinases that phosphorylates and E3 ligases that ubiquitinates diverse proteins constitute two largest classes of enzymes coded by all eukaryotic genomes. Research in the last three decades or so have established phosphorylation as an indispensable step in diverse cellular signaling pathways. Similarly, ubiquitination is established to play part in almost all cellular pathways to include proteostasis, transcription regulation, genome fidelity via DNA repair, and cell-cycle progression. It is therefore imperative that defects in these pathways in human cause diverse diseases including various types of cancers and neurodegenerative disorders. Thus, deciphering the molecular basis of the specificities of both of these post-translational machineries is of prime importance to understand their functions and mechanisms that spatio-temporally regulate these enzymes.

Aims and Objectives

We have undertaken multiple research projects with an aim to unravel diverse aspects of ubiquitination machinery and their regulation and are also involved in a project that involves understanding of a orphan receptor kinase from leguminous plant *Arachis hypogea*. The latter project is carried out in collaboration with Prof. Maitrayee Dasgupta. The specific objectives taken during the course of work are as follows-

- Understanding the structural basis of discriminatory recognition of ubiquitin conjugating E2 enzymes by RING E3 ligases.

- Residue specific insight into the structure-function relationship of RING E3 ligases.
- Understanding the role of a gatekeeper tryptophan residue in regulating the activity of symbiosis receptor kinase (SYMRK).

Work Achieved

- E2:E3 recognition: Specific recognition of conjugating E2s by E3 ligases constitute a crucial step to maintain fidelity in ubiquitination as E3s dictate the substrate specificity while E2s determine the modification topology.We showed that subtle structural differences between E2s, not apparent due to overall structural conservation of the UBC-fold, play an equally critical role in determining their interaction with RING E3s. More interestingly, we identified a conserved glutamic acid to aspartic acid swap in the helix1 of E2s alter their E3 preference.
- Role of a conserved tryptophan residue in RING E3 in activity:Using database analyses and biochemical analysis on mutant proteins and binding measurements we show that monomeric RING E3s require a conserved tryptophan in their E2 binding site whereas dimeric E3s do not. Using binding measurements we show that dimeric E3s do not require the tryptophan as the activity of RING E3s is primarily dictated by their avidity towards the E2 ~ Ub thioesters rather than their affinity towards individual E2 or ubiquitin moieties. In fact, we demonstrate that the presence of tryptophan alleviates the need of dimerization for dimeric E3 ligase RNF4 and allows it to ubiquitinate even as a monomer and propose a model ofr evolution of RING E3s (Figure).
- ***Role of the Gatekeeper tyrosine in SYMRK:***We determined the crystal structure of gatekeeper mutants of SYMRK in apo form and also in complex with ATP analog AMP-PNP/Mg^{2+}. Studies are underway to understand the role of this residue from a structural perspective.

Future Research Plans

- Understanding the role of loop regions in the ubiquitin-fold domain of non-canonical E1 Uba6 in dictating its E2 specificity.
- Designing of synthetic E3 ligases against selective target.
- Altering the target specificity of symbiosis receptor kinase.

Students Awarded Ph.D.

- Ms. Prerana Agarwal Banka, (CU, 2018) Structural and Biochemical Analysis of Ubiquitin Conjugating (E2) Enzymes".

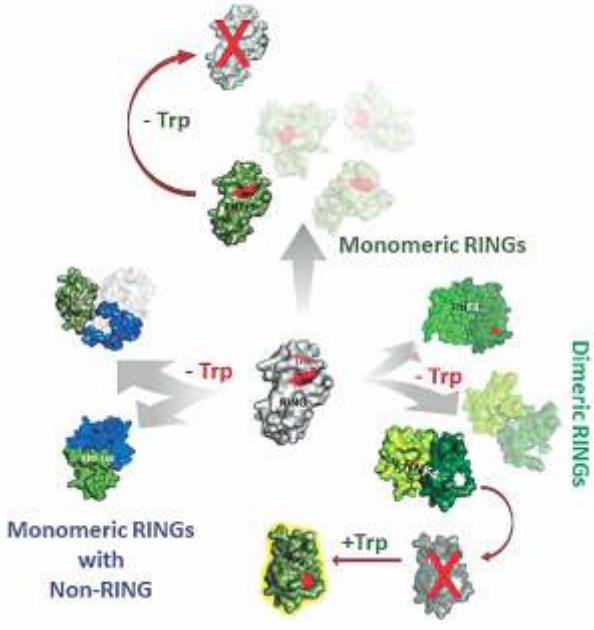


Figure.A model for the evolution of Ubiquitin RING E3 ligases. The ancestral RING, presumed to be a monomer contained the tryptophan. Addition of new domains or dimerization led to the substitution of the tryptophan with other residues to allow regulation of their activity. Thus mutating the tryptophan in monomeric RINGs destroys their enzymatic property whereas introduction of the tryptophan reinstates acticity in monomeric mutants of dimeric E3s.

DR. SRIMONTI SARKAR
Professor

Name of the Participants

Chumki Bhattacharjee, UGC Post-doctoral Fellow; Shankari Prasad Datta, INSPIRE Fellow; Nabanita Saha, UGC Fellow; Ananya Jana, Institute Fellow; Nabanita Patra, CSIR Fellow; Ankita Das, INSPIRE Fellow; Avishikta Chatterjee, INSPIRE Fellow; Pritha Mandal, CSIR Fellow.

Background

Giardia lamblia is a unicellular, flagellated protist that causes a widely-prevalent diarrhoeal disease, giardiasis. This disease is endemic to tropical regions and there is a high rate of incidence among economically-challenged populations of the developing world. Children are most susceptible and long-term consequences of repeated giardiasis include lower IQ and decreased growth. Emergence of strains resistant to existing anti-giardial drugs poses a significant threat. Besides its pathogenicity, *Giardia*is rapidly gaining attention as a model organism for the nascent field of evolutionary cell biology since its cellular machinery and architecture are significantly different from that of most eukaryotes. My laboratory uses molecular genetic approaches to study fundamental cellular processes of this pathogen that are vital for the spread of giardiasis in the community.

Aims and Objectives

We study molecular aspects of the pathogen's machineries for protein degradation and vesicular trafficking, vis-à-vis that of the host, aiming to uncover parasite-specific variances that may be leveraged to design new therapeutics. We also probe fundamental aspects of *Giardia*'s biology to understand how this organismcan engineer life with a genome that is ~200X smaller than the human genome. Fascinatingly, even with this limited genome space *Giardia* can support a life-cycle consisting of two different morphological stages (trophozoites and cysts), maintain a definite 'inverted tear-drop' cell shape, and also sustain movements that are specific for each of the functionally-unique four flagella pairs.

Work Achieved

Membrane remodeling is a fundamental requirement for various cellular processes and the ESCRT proteins constitute an ancient membrane sculpting machinery that causes membrane deformation away from the cytoplasm. The ESCRT machinery operates mainly on the surface of the endosome. We have documented that *Giardia*'s ESCRT machinery is composed of a limited number of proteins and this minimization has been achieved through removal of the functional redundancies that are known to be present within the ESCRT machinery of the host. For instance, of the three known functionally-redundant ESCRT subunits of yeast and humans, Vps46, Ist1 and Vps60, orthologues for only the first two have been retained in the reference *Giardia*s train, GL_50803. Further paring of redundancy appears to be in progress as even the gene for Ist1is in the process of being cleansed from the genome since it is present in only two of the five sequenced giardial isolates. This observed instance of genome dynamism in *Giardia* indicates that the plasticity of its genome may have paved the way towards constituting a minimal ESCRT machinery.

Future Research Plans

A minimized ESCRT machinery implies that the regulation of ESCRT complex assembly and disassembly is likely to be different in *Giardia*, compared to that of the host. We are dissecting the underlying sequence of events for the endosomal recruitment of the giardial ESCRT components. In addition, the regulation of the AAA-ATPase Vps4, a key component responsible for disassembly of the ESCRT machinery, is being probed to understand the subcellular locations at which this machinery operates and the cellular processes that are controlled by it.

Students Awarded Ph.D.

Atrayee Ray (University of Kalyani, 2018) Characterization of the subunits of the proteasomal lid of *Giardia lamblia*.

Publication(s)

Datta S P , Jana K , Mandal A, Ganguly S and Sarkar S (2018) Multiple paralogues of -SNAP in *Giardia lamblia* exhibit independent subcellular localization and redistribution during encystation and stress. *Parasit Vectors***11**:539. doi: 10.1186/s13071-018-3112-1

Department of Biochemistry

Book Chapters / Invited Reviews

Datta S P, Jana A, Saha N, Bhattacharjee C, and Sarkar S (2018) Phosphoinositides and Rab GTPases: identity markers of vesicular trafficking. In *Advances in Medico-Veterinary Parasitology: An Indian Perspective*, Editors: Arun K. Yadav, Veena Tandon and S. L. Hoti; Panima Publishing Corporation, New Delhi; 511p. 323-39 (Invited book chapter)

Invited Talks

June, 2018	DBT STAR COLLEGE Sponsored Summer School, Dept. of Microbiology, Lady Brabourne College
August, 2018	TEDx, National Institute of Technology, Trichy
September, 2018	Special Lectures in Advanced Cell Biology, Dept. of Biophysics and Molecular Biology, Calcutta University
March, 2019	National Lecture Series, Dept. of Zoology, North-Eastern Hill University

Conference(s) / Workshop(s)

August 2018 : 14th International Congress of Parasitology, Daegu, S. Korea (Abstract No. NO-0498).

DR. SUBRATA SAU

Professor

Name of the Participants

Mr. Debabrata Sinha, SRF; Mr. Soham Seal, SRF; Mr. Tushar Chakraborty, JRF.

Background

Staphylococcus aureus, a Gram-positive bacterium, causes various diseases to human and other animals. Currently, staphylococcal infections become a global health problem mainly due to the lack of vaccine and the appearance of the multiple antibiotic-resistant strains of this pathogen. To remove staphylococcal infections, one of the novel approaches would be the designing or screening of inhibitors capable of blocking its virulence factors and virulence regulators as these agents will not only weaken *S. aureus* but also reduce the chance of developing resistance against them.

Of the Staph proteins involved in pathogenesis, SarA acts as a global virulence regulator, whereas Cyp, a cyclophilin, acts as a virulence factor. Additionally, RsbW, an anti-sigma factor, blocks a sigma factor having a role in the *S. aureus*-mediated chronic infections. A repressor (CI), encoded by an *S. aureus* phage Phi11, also showed significant homology with many virulence factors. Structure, function, folding-

unfolding mechanism, and the stability of the above proteins have not been studied in details though having potentiality in drug discovery.

Aims and Objectives

- Understanding the structure, function, stability, and the folding-unfolding mechanism of SarA, Cyp, Phi11 CI, and RsbW using various probes.

Work Achieved

- SarA and RsbW formed two intermediates in the presence of chemical denaturants.
- Regions and residues of SarA, vital for preserving its structure, function, and stability, were identified.
- Phi11 CI and its two domains formed two intermediates in the presence of urea.
- Cyp produced one intermediate in the presence of urea (Fig. 1).

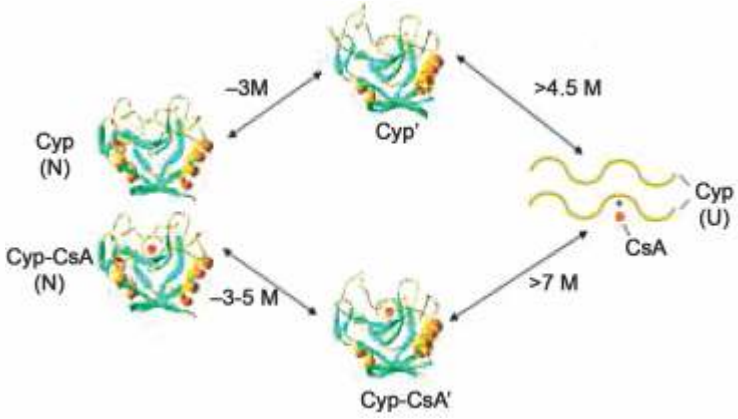


Fig. 1. Scheme of the urea-induced unfolding of Cyp and cyclosporin A (CsA)-bound Cyp. Cyp' and Cyp-CsA are the unfolding intermediates. N and U denote native and unfolded proteins, respectively.

Future Research Plans

- Work on RsbW and Cyp will be continued.
- To screen new antibacterials, a high-throughput assay system will be developed using Cyp as a bait.
- A new project entitled 'Studies on the structure, function, stability of a capsule producing enzyme from *Staphylococcus aureus*' will be initiated.

Students Awarded Ph.D.

Mr. Soumitra Polley (C.U. 2018) "Studies on the domains and domain-connecting helix of a peptidyl-prolyl *cis-trans* isomerase from *Escherichia coli*".

Publication(s)

I. Seal S, Polley S, Sau S (2019) A staphylococcal cyclophilin carries a single domain and unfolds via the formation of an intermediate that preserves cyclosporin A binding activity, *PLoS One*. 14(3):e0210771.

II. Biswas A, Ghosh S, Sinha D, Dutta A, Seal S, Bagchi A, Sau S (2018) Dimerization ability, denaturation mechanism, and the stability of a staphylococcal phage repressor and its two domains. *Int J Biol Macromol***.** 124:903-914.

III. Mandal S, Ghosh S, Sinha D, Seal S, Mahapa A, Polley S, Saha D, Sau K, Bagchi A, Sau S (2018) Alanine substitution mutations in the DNA binding region of a global staphylococcal virulence regulator affect its structure, function, and stability. *Int J Biol Macromol*. 113:1221-1232.

IV. Sinha D, Mondal R, Mahapa A, Sau K, Chattopadhyaya R, Sau S (2018) A staphylococcal anti-sigma factor possesses a single-domain, carries different denaturant-sensitive regions and unfolds via two intermediates, *PLoS One*. 13: e0195416.

V. Mahapa A, Mandal S, Sinha D, Sau S, Sau K (2018) Determining the Roles of a Conserved -Helix in a Global Virulence Regulator from Staphylococcus aureus; *Protein J*; 37:103-112.

Conference(s) / Workshop(s)

Debabrata Sinha and Subrata Sau presented a poster in the conference entitled "Nextgen Genomics, Biology, Bioinformatics & Technology" held at SciGenom Research Foundation, Jaipur from 30 Sept to 2 October, 2018.

Division of Bioinformatics

(Earlier known as Bioinformatics Centre, until November 2018)

Introduction

Today's Division of Bioinformatics started its journey three decades ago as a DBT funded BTIS Network's center at Bose Institute to offer Bioinformatics facility and skill-set. Later, full time research was started at the center and thereby it evolved as a 'Centre of Excellence in Bioinformatics', as graded by the DBT. The Bose institute has upgraded this center into its regular Division. The broader objectives of the research carried out in this division are to provide fundamental insights into Biology, to rationalize complex experimental observations, to make applications with long term goal to come up with scientific strategies for modern therapeutic approaches. The division has decent infrastructure of bioinformatics and computational biology research.

Faculty

Dr. Tapash C Ghosh, Professor (Superannuated on January 31, 2019); Dr. Shubhra Ghosh Dastidar, Associate Professor; Dr. Zhumur Ghosh, Associate Professor; Dr. Sudipto Saha, Assistant Professor; Prof. Pinakpani Chakrabarti, Chairman of the Bioinformatics Centre, until his superannuation in June 2018.




Division of Bioinformatics

Staff Members

Mrs. Sujata Roy, Technical Officer-I; Mr. Sanjib Kr. Gupta, Technical Officer-I; Mr. Jibananda Mondal, Helper; Mrs. Sharama Pradhan, Helper.

Students/RA/Project Assistant

Byapti Ghosh, JRF; Dr. Arpana Mukherjee, Woman Scientist; Sohini Chakraborty, Extended SRF; Troyee Das, JRF; Aritra Deb, Extended SRF; Sibun Parida, RA; Ranjan Kumar Maji, RA; Arijita Sarkar, Extended SRF; Abhirupa Ghosh, DBT JRF; Krishnendu Banerjee, ICMR project JRF; Shazia Firdous, UGC JRF; Sreyashi Majumdar, DST INSPIRE SRF; Saran N,BI SRF; Debangana Chakravorty, BI SRF; Tanmoy Jana, ICMR JRF; Souvik Sinha, SRF; Debadrita Basu, JRF; Debarati Paul, JRF; Abir Paul, JRF, Nishita Mandal, DBT-CoE Trainee; Dr. Uttam Kumar Basak, RA, Dr. Kamalika Sen, Woman Scientist; Kakali Biswas, SRF; Manish P Victor, SRF; Aranyak Goswami, NPDF; Deeya Saha, SRF; Debarun Acharya, SRF; Jesmita Dhar, SRF; Abir Pal, JRF; Sudipta Bag, RA.

Ms. Jesmita Dhar
Winner of Prof. B. B. Biswas
Outstanding Student Award 2018

Division of Bioinformatics

DR. SHUBHRA GHOSH DASTIDAR

Associate Professor

Name of the Participants

Souvik Sinha, SRF; Debadrita Basu, JRF; Debarati Paul, JRF; Abir Paul, JRF; Nishita Mandal, DBT-CoE Trainee; Dr. Uttam Kumar Basak, RA.

Background

Ares of Specialization: Structural dynamics of biomolecules, using theoretical and computational methods.

The atoms and molecules in nature are always jiggling and bumping into each other which form the basis of their collective properties. Therefore the structure-function relationship of molecules in life science is often non-trivial to understand just from the static models of molecular structures. To go beyond, computer simulations offer scopes to witness the atoms in action, mimicking a more realistic behavior of the molecular structures and tell how exactly they are meaningfully choreographed in order to perform or not to perform a function. We address the questions in structural biology whose answers are not trivially obtainable from the static structures and may require insights from the dynamics of the atoms, which we obtain from the computer simulations of the molecular systems of interest as described in the following sections.

Division of Bioinformatics

Aims and Objectives

The broader objective of the group is to provide structural and dynamical insights into the fundamental processes in biology using atomistic molecular modeling and simulations. We have been working in the several areas of Biophysical Chemistry and Structural Biology, e.g. protein-protein, protein-ligand and protein-lipid interactions, structure refinement, solvation, membrane properties etc. Bcl2 family, microtubule dynamics, p53-pathway are the primary systems of interest, which are promising areas of cancer therapeutics. Recent achievements have provided mechanistic insights into of the role of flexibility to modulate protein-protein interactions and have high implications in designing novel therapeutics.

Work Achieved

During this year under report, our major achievements include the following: (i) We have revealed how flexibility of the pro-apoptotic proteins Bcl-xl and Mcl-1enables them to discriminate between ligands which they prefer to bind, (ii) How the microclusters of Water Inside the , -Tubulin Core determine the quasi degeneracy of the Conformational States of its promising ligand E7010 (iii) made substantial progress to understand the role of polar residues in the membrane anchoring of Bcl-xl to determine its mechanism of membrane insertion.

Future Research Plans

We plan to extend our investigations on the mechanism of function of , -Tubulin dimer and how it can interfere with the ligands. We have just begun to understand how the ligands interfere with the intrinsic dynamics of the dimer that leads to allosteric changes in the structures and there are more which are yet to be understood. We will also continue to work on the Bcl2 family of proteins to understand their structure-function relations and in connection with their role in apoptosis. The mechanism of permeation of the peptides into membrane is another front of our investigations. All these areas of research has direct correlation with the understanding of the molecular mechanism to combat cancers.

Students Awarded Ph.D.

Dr. Atanu Maity, PhD (Biochemistry), "Flexibility and Conformational Modulations of Proteins Correlating Apoptosis: Molecular Dynamics Simulations of Bcl2 Family Members".

Publication(s)

(i) Chakraborty J, Priya P, Dastidar SG, Das S (2018) Physical interaction between nuclear accumulated CC-NB-ARC-LRR protein and WRKY64 promotes EDS1 dependent Fusarium wilt resistance in chickpea; *Plant Sci.;* 276:111-133.

(ii) Maity A, Majumdar S, Ghosh Dastidar S, (2018) Flexibility enables to discriminate between ligands: Lessons from structural ensembles of Bcl-xl and Mcl-1; *Comput Biol Chem*; 77:17-27.

Invited Talks

Bioinformatics workshop at Dhaka University, April 2018

National workshop of BIF at University of Kalyani, March 2019

Extramural Funding

Mechanistic insight into the ligand induced perturbation on the intrinsic dynamics and conformational sampling of the , dimer of Tubulin: Applications to combat cancer, funded by DST-SERB, Rs. 30,80,000, Stating date: 12/9/2016 for 3 years.

Division of Bioinformatics

DR. SUDIPTO SAHA
Assistant Professor

Name of the Participants

Abhirupa Ghosh, DBT JRF; Krishnendu Banerjee, ICMR project JRF; Shazia Firdous, UGC JRF; Sreyashi Majumdar, DST INSPIRE SRF; Saran N, SRF; Debangana Chakravorty, SRF; Tanmoy Jana, ICMR SRF.

Background

The overall goal of our lab is to improve diagnosis, prognosis, and treatment of lung diseases using bioinformatics and systems biology approaches. The research areas of our lab are the following:

- Clinical biomarkers and drug targets for asthma and COPD
- Identifying small chemical modulators of protein-protein interactions for drug discovery
- Drug Resistance in Mtb and in other bacterial species
- Identifying regulatory networks in Pluripotent Stem cells and Lung Cancer Stem Cells (lCSCs)

Aims and Objectives

- Identify biomarkers and drug targets of atopic asthma patients using proteomics approach
- Developing a database of pluripotent stem cell integrated regulatory interactions

- Developing a web server for prediction of linear peptide sequences binding to SH3, WW and PDZ domains.
- Developing a tool to predict IC50 value of small chemicals targeting protein-protein interactions.

Work Achieved

- Differentially expressed proteins in blood plasma of healthy controls (n = 5) and treatment-naive atopic asthma patients (n = 5) were identified by quantitative label-free LC-MS/MS proteomics and ELISA. MS-based proteomic analysis revealed Apolipoprotein E (Apo E) to be significantly down-regulated in atopic asthmatics as compared to healthy volunteers. Decreased expression of Apo E in atopic asthmatics was validated by immunoblotting (50.74% decrease).
- PSCRIdb (http://bicresources.jcbose.ac.in/ssaha4/pscridb) database was developed, comprising of pluripotent stem cell regulatory interactions integrating protein-protein, protein-DNA, gene-gene and miRNA-mRNA interactions in the mouse and human pluripotent cells.
- LMDIPred web server (http://bicresources.jcbose.ac.in/ssaha4/lmdipred), an online resource was developed for generalized prediction of linear peptide sequences that may bind to three most prevalent and well-studied peptide recognition modules (PRMs)-SH3, WW and PDZ.
- SVM regression based method was developed to predict the IC50 values (nM) of small molecule Protein-Protein interaction modulators.

Future Research Plans

- Compiling drug resistant gene mutations in Mtb, ESKAPE and other bacteria
- Understanding fluroquinolone (FLQ) resistant M. smegmatis using systems approach
- Validate predicted drug candidate(s) of asthma in mice model
- Update the Database of allergy and asthma database (DAAB)

Students Awarded Ph.D.

- Debasree Sarkar (CU, 2019) Systematic discovery of linear motifs mediating protein-protein interactions.
- Tanmoy Jana has submitted Ph.D thesis to Maulana Abul Kalam Azad University of Technology, WB.

Publication(s)

- Sarkar D, Jana T, Saha S (2018) LMDIPred: A web-server for prediction of linear peptide sequences binding to SH3, WW and PDZ domains. *PLoS One*. 12;**13**(7):e0200430.
- Majumdar S, Ghosh A, Saha S (2018) Modulating Interleukins and their Receptors Interactions with Small Chemicals Using In Silico Approach for Asthma; *Curr Top Med Chem*. 18(13):1123-1134.

Division of Bioinformatics

Book Chapters / Invited Reviews

- Chakravorty D, Banerjee K and Saha S (2018) Integrative Omics for Interactomes**,** In book: *Synthetic Biology,* S. Singh (ed.), Springer Nature Singapore Pte Ltd, pp 39-49 .

Invited Talks

- Sudipto Saha presented a paper at International Conference on Bioinformatics (InCoB), 2018, New Delhi titled "Prediction of half-maximal inhibitory concentration (IC50) for small chemical modulators targeting protein-protein interaction using support vector machine" (September 26-28, 2018).
- Sudipto Saha gave an invited talk at VIBCON-2018, Dimapur, Nagaland on "Predicting small chemical modulators of protein-protein interactions for drug discovery in lung diseases" (December 13-15, 2018).
- Sudipto Saha gave an invited talk at Indian Institute of Technology Jodhpur on "Understanding lung diseases using bioinformatics and systems biology approaches" (February 14, 2019).
- Sudipto Saha gave an invited talk at National Conference on Emerging Trends in Disease Model systems, organized by NCCS Pune on "Systematic discovery of biomarkers and drug targets of atopic asthma using proteomics approach" (March 25-26, 2019) .

Extramural Funding :

- Systematic identification of regulatory networks in pluripotent cells integrating coding and noncoding world. BIC/12(30)/2012 from 2017.3 to 2020.2, ICMR

Awards / Honours / Memberships

- European Respiratory Society Member, 2018-2019
- Chaired a session at International conference on Bioinformatics InCoB 2018, New Delhi (Session-XIX Structure, Function and Interactions-III, dated September 27, 2018)

Conference(s) / Workshop(s)

- Krishnendu Banerjee and Debasree Sarkar attended EMBL-EBI Workshop on "Analysis of genome scale data from bulk and single-cell sequencing" held in National Institute of Biomedical Genomics (NIBMG), Kalyani, India (November 19-23, 2018).
- Debangana Chakravorty, attended EMBO Practical Course on "Computational analysis of protein-protein interactions: Sequences, networks, and diseases" held in Rome, Italy with EMBO Travel Grant award (November 5-10, 2018).
- Sreyashi Majumdar attended and presented a poster titled "DAAB-V2: An updated version of Database of Allergy and Asthma Biomarkers with SNPs, Protein Interactors and Drug Information" in the Joint Congress of the Asia Pacific Association of Allergy, Asthma and Clinical Immunology & the Asia Pacific Association of Pediatric Allergy Respirology and Immunology (APAAACI & APAPARI), 2018, Bangkok, Thailand (October 11-14, 2018).

- Sreyashi Majumdar attended and presented a poster titled “Improving diagnosis, prognosis, and treatment of lung diseases using bioinformatics and systems biology approaches” in Pulmocon, 2018, Kolkata. She won the best poster award for the said poster (September 8-9, 2018:).
- Debangana Chakravorty presented a poster titled "FBXW7 and Skp2 mediated c-Myc degradation: An in silico approach" 'in International Conference on Bioinformatics (InCoB), 2018, New Delhi (September 26-28, 2018).
- Tanmoy Jana presented a poster titled "PPIMdb: A database of small chemicals modulating (inhibiting) protein-protein interactions" in International Conference on Bioinformatics (InCoB), 2018, New Delhi (September 26-28, 2018).
- Abhirupa Ghosh attended NIBMG Summer School 2018 on Systems Biology at National Institute of Biomedical Genomics (NIBMG), Kalyani, WB (July 17-21,2018).

Division of Bioinformatics

DR. TAPASH C GHOSH
Professor

Name of the Participants

Kakali Biswas (SRF, Rajib Gandhi Fellow); Manish Prasad Victor (SRF, Institute Fellow); Dr. Aranyak Goswami (National Post Doctoral Fellow) and Dr. Kamalika Sen (DST Woman Scientist).

Background and Objectives

Evolutionary Bioinformatics

Different proteins evolve at different rates. Elucidation of the determinants of the rate of protein sequence evolution is one of the great challenges in evolutionary biology. The main theme of our research goal is to identify and understand the different evolutionary forces by analyzing the genomic and functional data of various organisms.

Very briefly, the major results of the last one year (2018-19) are as follows:

Codon usage studies of Saccharomyces cerevisiae from codon usage pattern and structural stability of mRNA.

Important Findings

- Both codon usage bias and mRNA structural stability positively regulate mRNA expression levels in *Saccharomyces cerevisiae*.
- The naturally occurring codon composition is responsible for optimized mRNA expression.
- Under the natural codon composition, the mRNA structure having highest stability is selected by nature.

Evolutionary studies of the metabolic genes of Arabidopsis thaliana.

Important Findings

- Primary metabolic genes(PMGs) are primitive and persistent than secondary metabolic genes(SMGs) in *Arabidopsis thaliana*.

- This difference is primarily correlated with intron number and is independent of gene expression level.
- Intron enrichment in PMGs increases protein versatility by alternative splicing and acquisition of functional domains.
- Single nucleotide polymorphisms (SNPs) accumulate at a higher rate in introns as compared to exons.

Evolutionary studies on different types of hub proteins in human housekeeping and tissue-specific protein interaction

Important findings

- In a protein-interaction network (PPI), multi-interface (MI) hubs evolve slower than single-interface (SI) hubs.
- Among tissue-specific and housekeeping PPI, MI hubs evolve slower than SI hubs in tissue-specific group only.
- Protein's own properties as well as its partners' properties contribute to this evolutionary rate heterogeneity.

Publications

1. Victor MP, Acharya D, Begum T, Ghosh T C (2018) The optimization of mRN expression level by its intrinsic properties-Insights from codon usage pattern and structural stability of mRNA. *Genomics*. pii: S0888-7543(18)30374-4. doi: 10.1016/j
2. Sen K, Bhattacharyya D, Sarkar A, Das J, Maji N, Basu M, Ghosh Z, Ghosh T C (2018) Exploring the major cross-talking edges of competitive endogenous RNA networks in human Chronic and Acute Myeloid Leukemia. ***Biochim Biophys Acta Gen Subj***. 1862(9):1883-1892. doi: 10.1016.
3. Mukherjee D, Saha D, Acharya D, Mukherjee A, Chakraborty S, Ghosh T C (2018) The role of introns in the conservation of the metabolic genes of Arabidopsis thaliana. *Genomics*. 2018 Sep;110(5):310-317. doi: 10.1016/j.ygeno.2017.12.003. Epub 2017 Dec 13.
4. Biswas K, Acharya D, Podder S, Ghosh TC (2018) Evolutionary rate heterogeneity between multi- and single-interface hubs across human housekeeping and tissue-specific protein interaction network: Insights from proteins' and its partners' properties. ***Genomics.*** 110(5):283-290. doi: 10.1016/j.ygeno.2017.11.006. Epub 2017 Dec 2.

Student Awarded Ph.D.

Debarun Acharyya**,** 2018 (December), The importance of Human Duplicated Genes: Insights from evolutionary perspective.

Division of Bioinformatics

DR. ZHUMUR GHOSH
Associate Professor

Name of the Participants

Troyee Das, CSIR-JRF; Byapti Ghosh, DST Inspire JRF; Ranjan Kumar Maji, CSIR-RA; Aritra Deb, Institute SRF; Dr. Arpana Mukherjee, SERB WOS-A; Sibun Parida, Project RA.

Background

Our lab has the main focus to understand the role of regulatory noncoding RNAs in cancer and early embryonic development where stem cell plays a crucial role.

Our lab's vision is to develop relevant tools and databases (aligned to our lab's research focus) which will boost nation- wide implementation of omics facilities in clinical settings by efficient big data management so as to promote personalized therapy in India.

Aims and Objectives

Aim 1: Investigating the role of regulatory microRNAs(miRNAs), piwil interacting RNAs(piRNAs) and long noncoding RNAs(lncRNAs) in cancer and early embryonic development

Aim 2: Implementing systems approach to elucidate shortest paths of gene interaction within different cancer systems to have a better understanding of the disease progression

Aim 3: Role of regulatory RNAs and transcription factors in maintaining cellular pluripotency and their differentiation

Work Achieved

A. Investigating the role of regulatory RNAs in cancer stem cells: (a) Determined the microRNA and mRNA pool within the stem cell like sorted population from the AML cell line KG1a . We have elucidated the potential miRNA-mRNA pairs within these dataset. Subsequent experimental validation are ongoing. (b) We have generated the piRNA profile in human Ovarian teratocarcinoma OVTC cell line PA1 and is investigating whether piRNA promotes OVTC by maintaining cancer stem cell/progenitor populations.

B. Developed miRTPred for predicting miRNA targets, available at http://bicresources.jcbose.ac.in/zhumur/mirtpred (IEEE/ACM Trans Comput Biol Bioinform. 2018).

C. We have investigated the gene expression profiles of each grades of a specific type of glioma known as astrocytoma (brain tumor) by mapping Shortest Paths (SP) of gene interaction in each grade, and have identified module core genes provide interesting insight into the biology of astrocytic tumors and are potential therapeutic targets for astrocytoma (J Cell Physiol 2018).

Future Research Plans

(a) Detecting the role of miRNAs as epigenetic modulators inducing oncogenicity in stem cell derivatives.

(b) Identifying SNP-associated lncRNAs in most predominant female cancers in India.

(c) Studying the role of regulatory noncoding RNAs(ncRNAs) as regulators during fertilization and early stages of murine development and identifying potential ncRNA-mRNA interaction which is having significant role in determining fertility.

Students Awarded Ph.D.

(a) Arijita Sarkar (CU, 2018) Regulatory Networks Modulating Cellular Reprogramming in Stem cells.

(b) Sohini Chakraborty (CU, 2018) Role of Regulatory RNAs in modulating Stem Cell Biology.

Publications

(a) Mondal S, Maji RK, Ghosh Z, Khatua S (2018) ParStream-seq: An improved method of handling next generation sequence data. *Genomics*. pii: S0888-7543(18)30510-X. doi: 10.1016/j.ygeno.2018.11.014 (doi: 10.1016/j.ygeno.2018.11.014).

(b) Chakraborty S and Ghosh Z (2018) A systemic insight into astrocytoma biology across different grades. *J Cell Physiol*, https://doi.org/10.1002/jcp.27193 (doi: 10.1002/jcp.27193).

Division of Bioinformatics

(c) Maji RK, Khatua S, Ghosh Z (2018) A supervised ensemble approach for sensitive microRNA target prediction. *IEEE/ACM Trans Comput Biol Bioinform*. doi: 10.1109/TCBB.2018.2858252. PMID: 30040648.

(d) Sen K, Bhattacharyya D, Sarkar A, Das J, Maji N, Basu M, Ghosh Z, Ghosh TC (2018) Exploring the major cross-talking edges of competitive endogenous RNA networks in human Chronic and Acute Myeloid Leukemia. *Biochim Biophys Acta*;1862(9):1883-1892. doi: 10.1016/j.bbagen.2018.06.002. Epub 2018 Jun 15. PMID: 29902552.

(e) Datta C, Subuddhi A, Kumar M, Lepcha TT, Chakraborty S, Jana K, Ghosh Z, Mukhopadhyay AK, Basu J, Kundu M (2018) Genome-wide mRNA-miRNA profiling uncovers a role of the microRNA miR-29b-1-5p/PHLPP1 signalling pathway in Helicobacter pylori-driven matrix metalloproteinase production in gastric epithelial cells. *Cell Microbiol***.** 20(9):e12859. doi: 10.1111/cmi.12859. Epub 2018 May 25.

(f) Sarmah D, Agrawal V, Rane P, Bhute S, Watanabe M, Kalia K, Ghosh Z, Dave K R, Yavagal D R, Bhattacharya P (2018) Mesenchymal Stem Cell Therapy in Ischemic Stroke: A Meta-analysis of Preclinical Studies. *Clin Pharmacol Ther***.** 103(6):990-998. doi: 10.1002/cpt.927. Epub 2018 June103(6):990-998. Review. PMID: 29090465.

Book Chapters / Invited Reviews

(a) Sarkar A and Ghosh Z. (2019) Rejuvenation of piRNAs in emergence of cancer and other diseases; in AGO-driven Non-Coding RNAs: Codes to Decode the Therapeutics of Diseases, Elsevier. Pages 319-333

(b) Chakraborty S and Ghosh Z (2019) MicroRNAs Shaping Cellular Reprogramming; in AGO-driven Non-Coding RNAs: Codes to Decode the Therapeutics of Diseases, Elsevier. Pages 75-97.

Extramural Funding

(a) SERB grant started from March 2017; Elucidating the GWAS-Associated Genetic Variants within lncRNA candidate loci: Role in Cancer.

(b) ICMR project jointly with Dr. Sudipto Saha started from March 2017; Systematic identification of regulatory networks in pluripotent cells integrating coding and noncoding world.

(c) ICMR grant started from March 2017; Epigenetic Alterations inducing oncogenic transformation in stem cell derivatives.

(d) SERB Woman Excellence Award Grant started from July 2018; LncRNA target connectivity to Small Molecules: Implication in Cancer Therapy.

Patent(s)/Copyright(s)

1. piRNAQuest Diary No. 50940/2014-CO/L- This database contains information about piwil interacting RNAs and their annotation.
2. LncRBase Diary No. 50939/2014-CO/L- This database contains information about long noncoding RNAs and their annotation.

Awards / Honours / Memberships

(a) Received SERB Woman Excellence Award in April 2018

(b) Received NASI Scopus Young Scientist Award 2018

Conferences / Workshops

Poster Presentations

(a) Ghosh, B., Sarkar, A. and Ghosh, Z. Revealing the oncogenic signatures induced by miRNAs in iPSC-derivatives. 4th International Conference on Translational Research: Recent Development and Innovations in Human Health and Agriculture Research, Bogmallo Beach Resort, Goa, India, 11th-13th October, 2018.

(b) Parida, S., Sharma,D. and Ghosh, Z. AccessE-Algorithm to detect the accessible segments during LncRNA-mRNA interactions. Second International Conference on Advanced; Computational and Communication Paradigms (ICACCP-2019), Sikkim Manipal Institute of Technology, Sikkim, India, February 25 - 28 , 2019.

Department of Biophysics

Introduction

The Department of Biophysics was established in September 1983. Although a relatively young department and small in size, the department is very active in research primarily focused on Molecular Biophysics, Biophysical Chemistry and Structural Biology.The primary mission of the Department is to understand biological systems at a molecular level from a vantage point of physics, physical chemistry and computational chemistry, chemical and structural biology. This includes a detailed description in terms of molecular structure, conformation and dynamics and their interactions using both experimental and theoretical tools. In addition to generating fundamental knowledge in the field, the mission is to work in a collaborative fashion with other disciplines on fundamental as well as applied problems and solve them using cutting edge tools / methodologies

Department of Biophysics

Faculty

Dr. Gautam Basu, Professor and Chairman; Dr. Anirban Bhunia, Associate Professor; Dr. Subhrangsu Chatterjee, Associate Professor; Dr. Debjani Roy, Assistant Professor; Dr. Smarajit Polley, Assistant Professor.

Research Scantiests

Dr. Siddhartha Roy, J. C. Bose Fellow; Dr. Manju Roy, Visiting Scientist; Dr. Moitri Basu, DST-Inspire Faculty.

Staff Members

Baladeb Gaswami, Assistant Registrar-I (Superannuated on 31.12.2018), Basudeb Marick, Office Superintendent; Barun Majumder, Technical Officer-1; Tanmoy Debnath, Senior Laboratoty Assistant; Soumya Shankha Biswas, Junior Laboratory Assistant; Swapan Joghsharma, Helper-E; Sudhir Turi, Helper-E; Nagnarayan Yadav, Helper-E.

Students/RA/Project Assistant

Mr. Bankim Mondal, Mr. Anindya Dutta, Mr. Nilanjan Banerjee, Ms. Meghamukta Mukherjee, Ms. Swapna Bera, Ms. Sudakshina Ganguly, Dr. Aparajita Pal, Ms. Ananya Dutta, Ms. Bhawna Pandey, Mr. Dr. Aditya Dev, Dr. Piya Ghosh, Dr. Madhumita Chakraborty, Dr. Gitashree Naiya, Ms. Humaira Ilyas, Ms. Sonali Ghosh, Sk. Abdul Mohid, Ms. Pallabi Sengupta, Mr. Suman Panda, Mr. Chandradeep Basu, Mr. Dwijit Guha Sarkar, Dr. Debmitra Chakraborty, Ms.Nilanjana Maji, Dr. Trina Dutta, Mr. Dibakar Sarkar, Ms. Dipita Bhattacharyya, Ms. Pronita Roy, Dr. Gopa Dhar, Mr. Ranit Pariary, Dr. Supriya Das, Ms. Karishma Biswas, Ms. Shruti Mukherjee, Ms. Swarnali Kar, Ms. Prateeka Borar, Ms. Mitali Manna, Ms. Nabarupa Chowdhury, Dr. Swati Bhowmick, Ms. Deeparna Sutradhar, Mr. Samrat Mitra, Ms. Debapriya Bose, Dr. Payel Bhatterjee, Ms. Laboni Roy, Dr. Ipsita Chakraborty and Ms. Dipanwita Roy, Ananya Roy.

Ms. Pallabi Sengupta
Winner of Sir Nilratan Sirkar
Prize 2018

Department of Biophysics

DR. ANIRBAN BHUNIA
Associate Professor

Name of the Participants

Dipanwita Roy, JRF; Nabarupa Chowdhury, JRF; Karishma Biswas, JRF; Ranit Pariary, JRF; Dibakar Sarkar, JRF; Shruti Mukherjee, JRF; Dipita Bhattacharyya, SRF; Sk. Abdul Mohid, SRF; Humaira Ilyas, SRF; Swapna Bera, SRF; Bhisma N Ratha, SRF; Dr. Ipsita Chakraborty, RA.

Background

Biological membranes are an important functional interface for a plethora of physiological reactions, taking place within the cell. Thus all biological membranes serve as an indispensable platform for several surface proteins, membrane-integrated proteins/peptides and other ions and signalling molecules. The determination of molecular structure and dynamics of biomembranes and the associated functional peptides and proteins is, in fact, one of the most significant challenges in contemporary science. In this connection, vesicles and liposomes mimicking the lipid bilayer structure have been used to study membrane-protein/peptide interaction. Recently, nanodiscs, composed of lipid bilayer and membrane scaffold proteins (MSP), represent a more native environment than liposomes/ bicelles or detergent micelles. Recent

developments of NMR spectroscopy have facilitated in-depth characterization of the dynamics of interactions at the atomic-resolution. This precise structural knowledge is very much crucial to correlate with their membrane-directed functioning. Dr Bhunia's laboratory involves several biophysical techniques, including cutting-edge solid- as well as solution-state NMR spectroscopic techniques to characterize the membrane-associated functioning of several biologically active peptides and proteins.

Aims and Objectives

- Understanding the structural characterization of small amyloid oligomers at an atomic resolution.
- Membrane induced amyloid pathogenicity.
- Molecular mechanism of fibrillation of Amyloidogenic peptide and design of inhibitors.
- Rational design of antimicrobial peptides to develop pathogen-resistant transgenic plants
- Regulation of Lipopolysaccharide (LPS) induced signalling cascade in sepsis or septic shock.

Work Achieved

- Three-dimensional solution structure of several antimicrobial peptides targeting pathogenic model membrane mimic.
- Probed transient in amyloid beta (Ab40/42) fibril non-native states in A40 fibril formation by NMR.
- Understanding the role of Alzheimer pathogenicity from the investigation of core amyloid forming A40 fragments in membrane.
- Pioneer in determining three-dimensional solution structure in live cell.
- Decipher the epitope of early nucleation events for alpha-synuclein familial mutants using NMR.
- Probing the LPS binding structural motif in alpha-synuclein that modulates disease propagation from gut to brain.
- Developed reduced dimensionality experiments to record 3D HNCACB and CBCACONH to monitor the kinetics and dynamics of A fibrillation.
- Identified a non-toxic and serum stable heptapeptide that inhibits insulin amyloid fibrillation, implicated in Type II Diabetes.

Future Research Plans

- To develop nanodisc technology to study aggregation kinetics of Amyloid proteins.
- To trap early toxic oligomers using solution- and solid-state NMR in the presence of customized nanodisc technology.
- Designing inhibitors against toxic oligomers.

Department of Biophysics

Students Awarded Ph.D.

Aritreyee Datta (CU, 2018) Structural insights into de-novo designed antimicrobial peptides: mechanistic analysis against plant and animal pathogens.

Publications

1. Bhattacharyya D, Kumar R, Mehra S, Ghosh A, Maji S K, Bhunia A (2018) Multitude NMR Studies of alpha-Synuclein Familial Mutants: Probing their Differential Aggregation Properties. *Chemical Communications*. 54, 3605-3608.
2. Bhattacharyya D, Mohite G M, Krishnamoorthy J, Gayen N, Mehera S, Navalkar A, Kotler S A, Ratha B N, Ghosh A, Kumar R, Garai K, Mandal A K, Maji S K, Bhunia A (2019) Lipopolysaccharide from Gut Microbiota Modulates Alpha-Synuclein Aggregation and Alters its Biological Function. *ACS Chemical Neuroscience*. 10(5), 2229-36.
3. Bhattacharyya D, Kim M, Mroue K H, Park M S, Tiwari A, Saleem M, Lee D-K, Bhunia A (2019) Role of Non-electrostatic forces in Antimicrobial Potency of a Dengue-virus derived fusion peptide VG16KRKP: Mechanistic insight into the interfacial peptide-lipid interactions. *BBA* 1861, 798-809.
4. Brender J R, Ghosh A, Kotler S A, Krishnamoorthy J, Bera S, Morris V, Sil T B, Garai K, Reif B, Bhunia A, Ramamoorthy A (2019) Probing Transient Non-Native States in Amyloid Beta Fiber Elongation by NMR. *Chemical Communications*. 55, 4483 - 86.
5. Ghosh A, Bhattacharyya D, Bhunia A (2018) Structural Insights of a Self-assembling 9-Residue Peptide from the C-terminal tail of the SARS Corona Virus E-protein in DPC and SDS Micelles: A Combined High and Low Resolution Spectroscopic Study. *BBA - Biomembrane* 1860, 335-346.
6. Kar R K, Brender J R, Ghosh A, Bhunia A (2018) Non-productive Binding Modes as a Prominent Feature of A 40 Fiber Elongation: Insights from Molecular Dynamics Simulation. *Journal of Chemical Information and Modeling*. 58, 1576-86.
7. Mohid S A, Ghorai A, Ilyas H, Mroue K H, Narayanan G, Sarkar A, Ray S K, Biswas K, Bera A K, Malmsten M, Midya A, Bhunia A (2019) Application of Tungsten Disulfide Quantum Dot-Conjugated Antimicrobial Peptides in Bioimaging and Antimicrobial Therapy. *Colloids and Surfaces B: Biointerfaces* 176, 360-370.
8. Nandi S K, Chakraborty A, Panda A K, Kar R K, Bhunia A, Biswas A (2018) Evidences for Zinc (II) and Copper (II) Ion Interactions with Mycobacterium leprae HSP18: Effect on its Structure and Chaperone Function. *Journal of Inorganic Biochemistry*. 188, 62-75.
9. Nordström R, Nyström L, Ilyas H, Atreya H S, Borro B C, Bhunia A, Malmsten M (2019) Microgels as carriers of antimicrobial peptides - effects of peptide PEGylation. *Colloids and Surfaces A: Physicochemical and Engineering Aspects* 565, 8-15.
10. Pal I, Bhattacharyya D, Kar R K, Zarena D, Bhunia A, Atreya H S (2019) A Peptide-Nanoparticle System with Improved Efficacy against Multidrug-Resistant Bacteria. *Scientific Reports*. 9, 4485.

11. Pandit G, Ilyas H, Ghosh S, Bidkar A, Mohid S A, Bhunia A, Satpati P, Chatterjee S (2018) Insights into the Mechanism of Antimicrobial Activity of Seven-Residue Peptides. *Journal of Medicinal Chemistry*. 61, 7614-29. ([1]Both authors contributed equally).
12. Ratha B N, Kar R K, Kalita S, Kalita S, Raha S, Singha A, Garai K, Mandal B, Bhunia A (2019) Sequence Specificity of Amylin-Insulin Interaction: A Fragment-Based Insulin Fibrillation Inhibition Study. *BBA* 1867, 405-415.
13. Ratha B N, Kim M, Sahoo B, Garai K, Lee D-K, Bhunia A (2018) Insulin-Eukaryotic Model Membrane Interaction: Mechanistic Insight of Insulin Fibrillation and Membrane Disruption. *BBA - Biomembrane pii*: S0005-2736(18)30049-X.
14. Roy M, Kundu A, Bhunia A, DasGupta S, De S, Das A K (2019) Structural characterization of VapB46 antitoxin from Mycobacterium tuberculosis: insights into VapB46-DNA binding. *FEBS Journal* 286, 1174 - 90.
15. Zhang R, Zhang N, Mohri M, Wu L, Eckert T, Krylov V B, Antosova A, Ponikova S, Bednarikova Z, Markart P, Günther A, Bengt N, Billeter M, Schauer R, Scheidig A J, Ratha B N, Bhunia A, Hesse K, Enani M A, Steinmeyer J, Petridis A K, Kozar T, Gazova Z, Nifantiev N E, Siebert H C (2019) Nanomedical Relevance of the Intermolecular Interaction Dynamics - Examples from Lysozymes and Insulins. *ACS Omega* 4, 4206-4220.

Book Chapters / Invited Reviews

1. Bera S, Bhunia A (2019) Cell-Penetrating Peptides as Theranostics Against Impaired Blood-Brain Barrier Permeability: Implications for Pathogenesis and Therapeutic Treatment of Neurodegenerative Disease. In Blood-Brain Barrier, (Edited by T. Barrichello), Humana Press, New York, NY. Neuromethods. 142, pp 115-136.
2. Brender J R, Krishnamoorthy J, Ghosh A, Bhunia A (2018) Binding Moiety Mapping by Saturation Transfer Difference NMR. Rational Drug Design: Methods and Protocols : In *Methods in Molecular Biology*, (Edited by T. Mavromoustakos and T. Kellici) Springer Nature. 1824, pp 49-65.

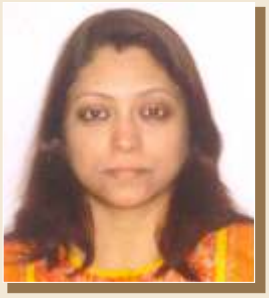
Invited Talk

1. Nuclear Magnetic Resonance Society (NMRS) conference, which was held at AIIMS, New Delhi in February 2019.

Extramural Funding

1. SERB (EMR/2017/003457); November 19, 2018 – November 18, 2021 (PI of the project).
2. DBT funding project: July, 2018 – July, 2021 (Co-PI of the project).

Department of Biophysics



DR. DEBJANI ROY
Assistant Professor

The Systems Biology approaches to study Huntington's Disease from Next Generation Sequencing Data obtained from various sources.

Huntington's disease (HD) is a PolyQ class of neurodegenerative disease results in the occurrence of a stretch of CAG (glutamine) repeat in the coding region of the disease-causing gene. Biological network analyses identified several co-expressed genes and their associated pathways. Experimental work is needed to validate these results in the future.

Experimental validations of the predicted drugs of Amyotropic Lateral Sclerosis (ALS) in human cell-based screening assays.

We have identified top 20 ALS drugs and their interactors in the human interactome. Further experimental work is needed to elucidate the effectiveness of these drugs in human cells.

Algorithm development of drug repositioning using differentially methylated CpGs and corresponding single nucloetide polymorphisms (SNPs).

We have identified several Parkinson's Disease (PD) related differentially methylated CpGs and corresponding single nucleotide polymorphisms (SNPs). Our work is aimed at developing model -based predictions to unravel the epigenetics of PD.

DR. GAUTAM BASU
Professor

Name of the Participants

Dr. Aditya Dev, RA; Dr. Debamitra Chakravorti, RA; Ms. Sudakshina Ganguly, SRF; Mr. Bankim Mondal, SRF; Mr. Chandradeep Basu, SRF; Ms. Bhavna Pandey, SRF.

Background

All biological phenomena are driven by specific molecular interactions via cognate recognition and non-cognate discrimination processes. Both recognition and discrimination are mediated by specific structural and dynamic elements of the interacting molecules. Therefore in order to understand molecular triggers of biological functions it is important to understand structure and conformations of molecules. Given known structures (or a known set of sequences), it is also important to know how different elements interact via specific or non-specific physical forces. In my lab we use biophysical, spectroscopic as well as computational tools to understand structural properties of biologically important molecules and their significance in biology.

Aims and Objectives

We work on a number of diverse projects with specific aims. Here are some specific objectives:

- Structure-function-evolution of aminoacyl tRNA-synthetases

- Peptide conformation and design
- Electrostatic interactions in biomacromolecules
- Tubulin dynamics
- Small molecule-DNA interaction

Work Achieved

- Solved the structure of *E. coli* and *M. fumariolicum* glutamyl-tRNA synthetase structure
- Identified unique role of *cis*Pro in designed peptides and natural proteins
- Determined the DNA-bound structure of a novel near IR fluorescent probe
- Identified mechanism of loop dynamics associated with drug binding in tubulin
- Identified novel supersecondary structural change in DNA induced by a quinoxaline derivative and doxorubicin

Future Research Plans

In the next two years some projects that we would like to pursue are:

- Solve the following crystal structures: (a) *M. fumariolicum* GluRS bound to tRNA, and possibly gatCAB. (b) complex between a peptide from the p53 C-terminal domain and PC4 (c) pyrene labeled crenactin
- Study interactions between DNA and TC (a novel DNA binding probe)

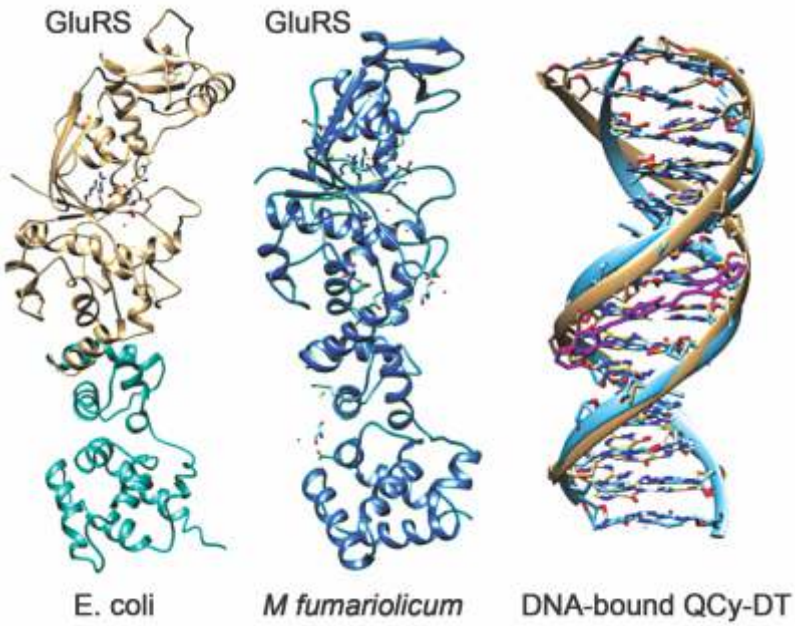


Figure 1. X-ray crystal structures of GluRS from *E. coli* and *M. fumariolicum*, and the DNA (5'-CGCGAAATTTCGCG-3') bound structure of QCy-DT.

- Understand the role of cisPro in designed hairpins and IDP
- Help develop lead molecules that disrupt PC4-p53 interactions

Students Awarded Ph.D.

Sarbani Chattopadhyay (CU, 2018) Molecular Dynamics Simulations of Peptides & Proteins: Structural and Functional Insights.

Publications

1. Bera S, Dhar J, Dasgupta R, Basu G, Chakraborti S, Chakrabarti P (2018) Molecular features of interaction involving hen egg white lysozyme immobilized on graphene oxide and the effect on activity. *Int. J. Biol. Macromol.* 120B:2390-2398.
2. Chandra N, Biswas S, Rout J, Basu G, Tripathy U (2019) Stability of -turn in LaR2C-N7 peptide for its translation-inhibitory activity against Hepatitis C viral infection: A molecular dynamics study. *Spectrochim. Acta A Mol. Biomol. Spectrosc.* 211:26-33.
3. Mahata T, Chakraborty J, Kanungo A, Patra D, Basu G, Dutta S (2018) Intercalator-Induced DNA Superstructure Formation: Doxorubicin and a Synthetic Quinoxaline Derivative. *Biochemistry* 57:5557-5563.

DR. SMARAJIT POLLEY
Assistant Professor

Name of the Participants

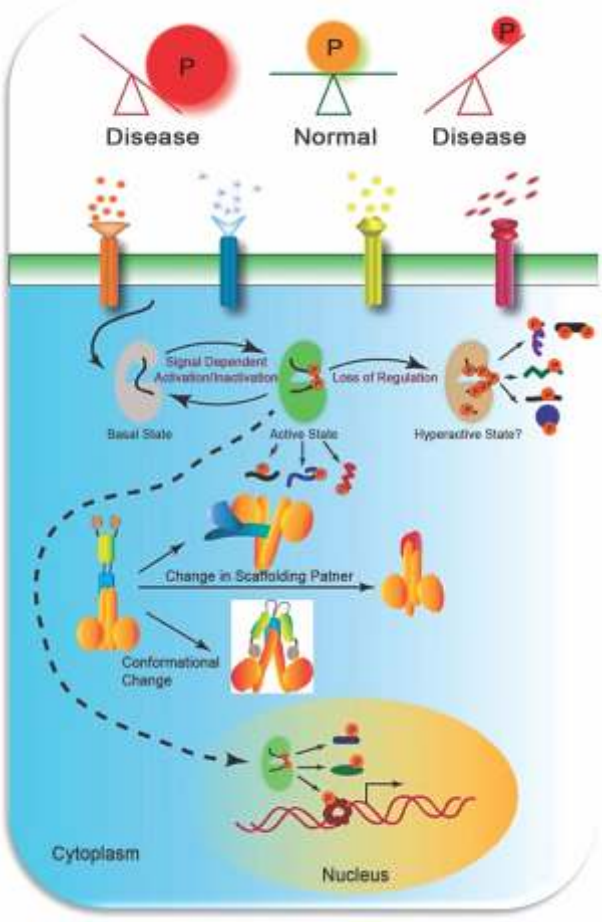
Pranita Ray, JRF; Prateeka Borar, JRF; Deeparna Sutradhar, JRF; Samrat Mitra, JRF; Dr. Dwijit Guha Sarkar, RA; Dr. Trina Dutta, RA.

Background

Multicellularity is the most complex form of life. Well-being of multicellular organisms depend upon delicate balance and fine-tuned regulation of inter- and intra-cellular signalling pathways. We primarily use biochemical, chemical and structural biology tools to understand the mechanistic details of a few key signalling pathways at highest resolution. Protein kinases and transcription factors are at the centre of attention in the laboratory.

More than 500 protein kinases are encoded in the human genome.Protein kinases provide the regulatory framework for most signaling pathways in eukaryotic cells. They add phosphate groups to amino acid residues and create modified chemical entities that provide altered functionality to protein substrates. Stringent regulation of their activities is critical to proper functioning of cellular processes, which often make them interesting point of intervention in many pathological scenarios. Many eukaryotic kinases show signaling modularity entailing distinct outcomes, both beneficial and

harmful in a context dependent manner. Indiscriminate inhibition of these activities often has deleterious effect. Signaling modularity is dictated by choice of substrates, cognate-binding partners, subcellular localization and post-translational modifications of the kinase itself. We investigate the mechanistic details of their activation and spatio-temporal regulations to fully realize the scope of modulating them in a manner beneficial for the organism. We work primarily on two model kinase systems: a) Inhibitor of kappaB Kinases (IKK), gateway to NF-kB activation and b) Dual Leucine Zipper Kinase 1 (DLK1), a major player in axonal regeneration.



Aims and Objectives

The primary focus of the lab is to understand structural and biochemical basis of IKK and DLK1 activation in a context dependent manner. To attain these objectives, we have split them into the following goals:

- Determine the high-resolution structures of IKK and DLK1 complexes.
- Understanding the structural basis of scaffolding protein dependent signaling of IKKs and DLK1.
- Chemical biology and omics-based approaches to unravel hitherto unknown substrates of IKKs, DLK1 and related protein kinases.

Work Achieved

- Establishment of insect cell culture facility for large scale expression of eukaryotic proteins.
- Establishment of chemical genetics approach to identify hitherto unknown substrates of protein kinases.
- Identification of two hitherto unknown substrates of IKK2 *in vitro*. It is still unreported what roles might these phosphorylation events play in regulating NF-kappaB or other cellular signaling pathways.
- Establishment of remote processing of cryo-EM data and structure determination (in collaboration with The Salk Institute). This study provides clues to many aspects of filament formation by non-cytoskeletal proteins. In this case a type II restriction enzyme was used as a model system. It deciphers the mechanism enzyme filamentation and its advantageous role in bacterial immune protection against phage. It also indicates why are filament-forming enzymes so efficient in catalysis than their non-filamentous counterparts.

Department of Biophysics

Future Research Plans

- Decipher the structure-function relationships of NF-kappaB activating protein kinase complexes.
- Identify not yet known substrate space of IKKs using chemical genetics and omics approaches.

Publication(s)

1. Polley Smarajit, Hunag De-Bin, Biswas Tapan and Ghosh Gourisankar (2018) A guide to production, crystallization, and structure determination of human IKK1/ , *Journal of Visualized Experiments.*; *e56091*. doi:10.3791/56091.

Invited Talks

a) Invited Lecture at International Conference on Green Engineering and Sustainable Development; Aug 20-21, 2018 at Mugberia Gangadhar Mahavidyalaya, West Bengal.

b) Invited Lecture at EMSI (Electron Microscopy Society of India) 2018 Annual meeting; July 18-20, 2018 at Bhubaneshwar.

Extramural Funding

DBT Wellcome Trust India Alliance Intermediate Fellowship. Project title:"*Understanding the Biochemical and Structural Basis of Signaling Modularity of Kinases in Their Biological Context*".Status: *Ongoing*

Conference(s) / Workshop(s): 1 (International).

International Symposium on Frontiers in Development and Molecular Medicine: Models to Insights; March 1-3, 2019 in Kolkata.

DR. SUBHRANGSU CHATTERJEE

Associate Professor

Name of the Participants

Meghomukta Mukherjee, SRF; Pallabi Sengupta, SRF; Nilanjan Banerjee, SRF; Anindya Dutta, SRF; Ananya Roy, SRF; Debopriya Bose, JRF; Gopa Dhar, RA; Laboni Roy, JRF.

Collaborators

Dr. Samit Chattopadhyay, Director, IICB, Kolkata; Dr. Tanya Das, Molecular Medicine, Bose Institute, Kolkata; Dr. Gaurisankar Sa, Molecular Medicine, Bose Institute, Kolkata; Dr. Partha Chakraborti, Principal Scientist, Cell Biology and Physiology, IICB, Kolkata; Dr. Moitri Basu, DST-Inspire Faculty Member, Department of Biophysics, Kolkata.

Background

The main goal of my research is to employ high resolution multidimensional (1D/2D/3D) NMR spectroscopy in the biophysical and structural studies of G-Quadruplex and G-Quadruplex binding protein/peptides. Both Nucleic Acid and Protein NMR in conjunction with the use of Molecular Dynamics simulation, Modeling and CD, Fluorescence, IR, TEM, SEM, other low resolution spectroscopy and cell biology experiments etc. are performed to unravel Nucleic Acid Protein interactions, Nucleic Acid-Drug/Ligand interactions, protein/peptide aggregation/dissociation and biomolecular folding and unfolding and gravity of those three dimensional

structural platforms in dictating disease biology like cancer.We also work on de novo design of anti-aggregation peptides against Insulin, A-beta peptides.

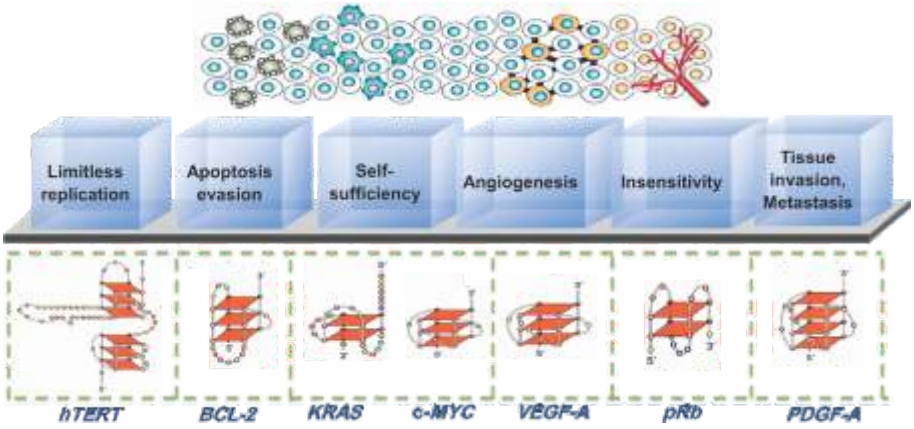


Fig1: G quadruplexes are found in oncogene promoters

Aims and Objectives

1. Understanding different sequenced solution structures of G-Quadruplexes and G-wires at the telomeres and onco gene promoters which are important three dimensional molecular platform in the stoppage of Cancer Cell Growth.
2. Designing, screening of small ligands, peptide, DNA/RNA aptamers selectively bind G-Quartet Structures. Solution of small peptide / ligand/ Aptamer-G quartet bound Solution structures.
3. NMR based Binding studies of Antimicrobial peptides (LL-37) with G-quartets. Calculation of solution structures, peptide bound to G quartets. This can be a novel approach in Cancer Cell death.
4. Developing Anti-Prion/Insulin/A-beta Peptides (APP) for the stoppage of pathogenesis.
5. Understanding Long Non Coding RNA/ miRNA scaffolds and their functions in causing cancers.

Work Achieved

We could unravel the following:

1. Mechanistic mechanism of Quadruplex-protein crosstalk in *c-MYC* promoter to control transcription homeostasis.
2. *De novo* synthesis of *c-MYC* quadruplex-specific probes and their mode of action in targeting *c-MYC* Quadruplex
3. Identification of Quadruplex in *MAPK12* promoter and its role in metastasis and cancer stemness regulation.
4. Identification of Quadruplex in *LINC00273* promoter and its role in metastasis and cancer stemness regulation.
5. Site-specific amino acid substitution in dodecameric peptides determines the stability and unfolding of c-MYC quadruplex promoting apoptosis in cancer cells
6. Generation of VEGF Quadruplex selective peptides that inhibits angiogenesis in cancer cell and finding out the signaling cascade through which the peptide works.
7. Regulation of ALT phenotype by stabilization of hybrid G quadruplex(GQ) present in SMARCAL1 promoter.

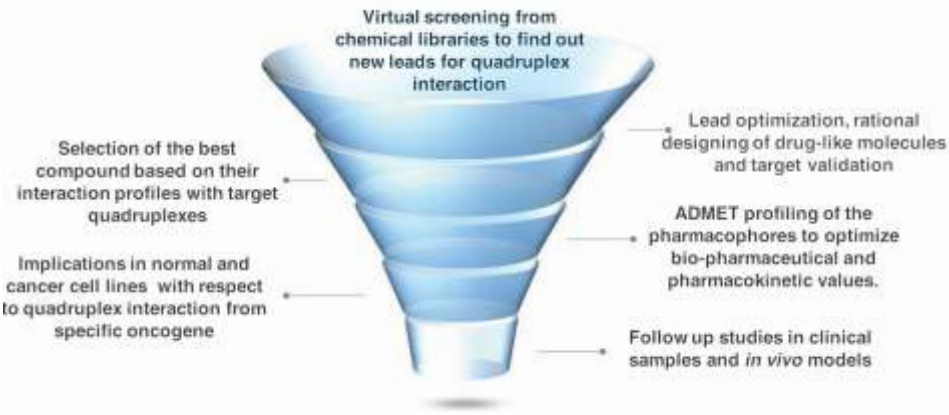


Fig2: Work Flow

8. Promoter G-quadruplex favours epigenetic reprogramming-induced atypical expression of ZEB1 in cancer cells. Out of the four putative G-quadruplex motifs in the promoter region of ZEB1, one is of particular importance since this is the site of tinary complex formation whereby Nucleolin binds to a particular G4 motif and attracts SP1 and P300 acetyltransferase which subsequently acetylates and remodels the local epigenetic landscape to induce ZEB1 transcription.

Future Research Plans

1. We will focus on LINC00273 long non coding RNA expression in tuning the immunity and stemness in cancer cells.
2. Designing new therapeutic peptides which selectively unfolds G-Quadrupplex at c-MYC promoter to stop aberrant c-MYC expression in cancer cells.
3. Designing small molecules/peptides impedes insulin aggregation.

Students Awarded Ph.D.

Jyotsna Bhat (CU, 2019) Insilico and Biophysical Investigation of G-quadruplex Structures: A Combinatorial Approach towards Novel Anticancer Therapeutics.

Ms. Soma Mondal (CU, 2019) Structural and biophysical aspects of G,C rich nucleic acids".

Publications

1. Kajal K, Panda A K, Bhat J, Chakraborty D, Bose S, Bhattacharjee P, Sarkar T, Chatterjee S, Kar SK, Sa G (2019) Andrographolide binds to ATP-binding pocket of VEGFR2 to impede VEGFA-mediated tumor-angiogenesis. *Sci Rep*. 11;9(1):4073. doi: 10.1038/s41598-019-40626-2.
2. Sengupta P, Bhattacharya A, Sa G, Das T, Chatterjee S (2019) Truncated G-Quadruplex Isomers Cross-Talk with the Transcription Factors To Maintain Homeostatic Equilibria in c-MYC Transcription. *Biochemistry*. 16;58 (15):1975-1991.
3. Sengupta P, Banerjee N, Roychowdhury T, Dutta A, Chattopadhyay S, Chatterjee S. (2018) Site-specific amino acid substitution in dodecameric peptides determines the stability and unfolding of c-MYC quadruplex promoting apoptosis in cancer cells. *Nucleic Acids Res*. 2;46 (19):9932-9950. doi: 10.1093/nar/gky824.

Department of Chemistry

Introduction

The Department of Chemistry was established in 1917, at the time of inception of the Institute. A major part of ShambhuNathDey's seminal work on the discovery of Cholera toxin was performed in this department for which he was nominated for the Nobel Prize. Over the course of time the department has adopted interdisciplinary research using the application of chemical principles to explore biological phenomena.

Present research activities of the department are

- Host-pathogen interaction: *Mycobacterium tuberculosis* and *Helicobactor Pylori*
- Stress response and signaling in *Mycobacterium tuberculosis*
- Recombinant approach to prokaryotic transcription
- Mathematical modeling of signaling pathway

Department of Chemistry

Faculty

Dr. Joyoti Basu, Professor, Dr. Jayanta Mukhopadhyay, Associate Professor, Dr. Suman Kumar Banik, Associate Professor

Staff Members

Mr. Dipak Ch. Konar, Technical Officer–I, Mrs. Rama Chatterjee, Office Superintendent, Transferred to Department of Biochemistry from 3.8.18 (vide order no. R/1554/18 dt 2.8.18), Mrs. Sujata Roy, Accountant, Transferred to Purchase Section from 7.1.19 (vide order no. R/91/(B)/19/3603 dt 3.1.19), Mr. Gaurab Kumar Roy, Senior Laboratory Assistant, Mr. Mrityunjoy Kundu, Senior Laboratory Assistant, Mr. Sachchidanand Ram, Upper Division Clerk, Mr. Asoke Kr. Maity, Helper-D, Mr. Subhas Chandra Paul, Helper-C.

Students/RA/Project Assistant

Arun Kumar Sharma, SRF-Extended, Suruchi Lata, SRF, Amar Chandra Mahatha, SRF, Madhurima Chatterjee, JRF, Shreya Bagchi, JRF, Debayan Majumder, JRF, Tuhin Subhra Roy, SRF, Ritu Jaiswal, JRF, Sourajit Saha, JRF, Aniruddha Tewary, JRF, Thurbu Tshering Lepcha, SRF, Pankaj Jankiram Birari, SRF, Arkajyoti Datta, SRF, Ayan Biswas, SRF, Soumya Mal, JRF, Manish Kumar, SRF-Extended, Soumya Mukherjee, NPDF, Md. Sorique Aziz Momin, JRF, Nilanjana Hazra, JRF, Arun Kumar Das, JRF

DR. JAYANTA MUKHOPADHYAY
Associate Professor

Name of the Participants

Dr Soumya Mukherjee, DBT-NPDF, Arkojyoti Dutta, Institute Fellow-SRF, Ritu Jaiswal, CSIR-JRF, Sourajit Saha, CSIR-JRF, Aniruddha Tewari, CSIR-JRF, Madhumita Chatterjee, DST Inspire Fellow, Nilanjana Hazra, Insitute Felow, JRF

Background and Aims :

Fundamental Mechanism of transcription and gene regulation in bacteria.

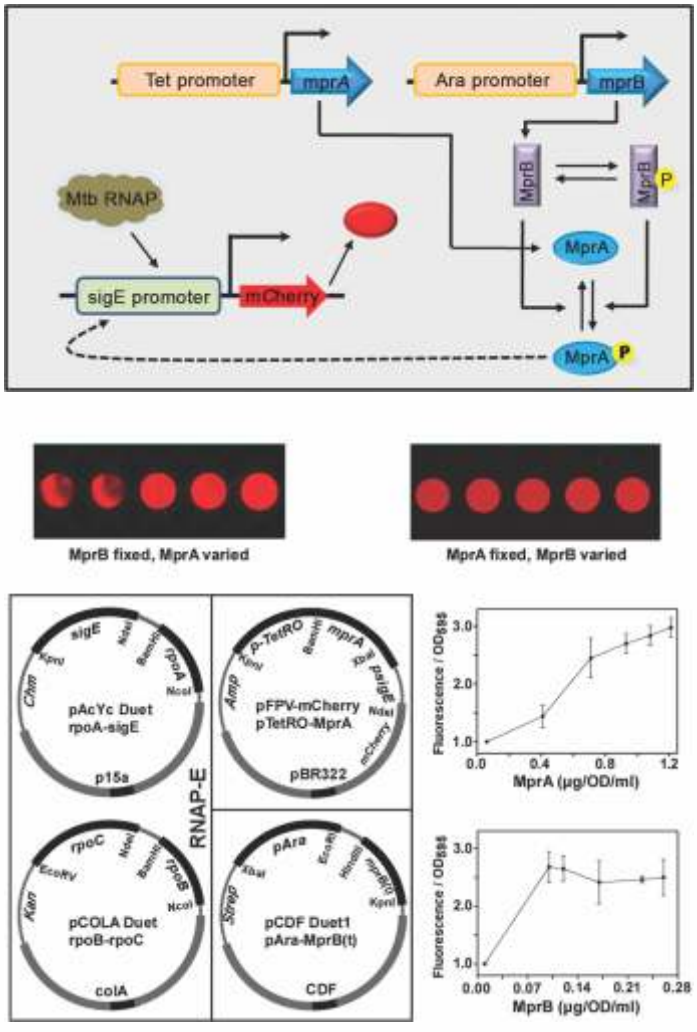
Transcription is the first step in gene expression where most regulation occurs and is one of the most important targets for antibacterial therapy. RNAP core enzyme together with sigma factor(s) and/or numerous regulator(s) orchestrates the gene expression in bacteria. Our lab seeks to characterize the interactions among RNAP, sigma factors, and regulators required for various gene expressions in prokaryote, e.g. *Escherichia coli*, *Bacillus subtilis* and *Mycobacterium tuberculosis*. We use integrated biophysical, biochemical and genetic approaches, along with a recombinant *in vitro* transcription system to address the following specific aims:

- Mechanism of gene regulation by various transcriptional factors and sigma factors in prokaryote.
- Identify and characterize inhibitors of M. tuberculosis gene expression.
- Identify new target for anti-tuberculosis agents.

Work Achieved

Evidence of robustness in a two-component system using a synthetic circuit

Variation in the concentration of biological components is inescapable for any cell. Robustness in any biological circuit acts as a cushion against such variation and enables the cells to produce homogeneous output despite the fluctuation. The two-component system (TCS) with a bi-functional sensor kinase (that possesses both kinase and phosphatase activities) is proposed to be a robust circuit. Few theoretical models explain the robustness of a TCS, although the criteria and extent of robustness by these models differ. Here, we demonstrate experimental evidence to validate the extent of the robustness of a TCS signaling pathway. We have designed a synthetic circuit in *Escherichia coli* using a representative TCS of *Mycobacterium tuberculosis*, MprAB and monitored the *in vivo* output signal by systematically varying the concentration of either of the components or both. We observed that the output of TCS is robust if the concentration of MprA is above a threshold value. This observation is further substantiated by two *in vitro* assays, in which we estimated the phosphorylated MprA pool or MprA dependent transcription yield by varying either of the components of TCS. This synthetic circuit could be used as a model system to



Schematic diagram of tuning and functioning of the MprAB TCS circuit: The protein MprA could be systematically varied by *tetRO* inducible promoter and MprB could be systematically varied by *ara* inducible promoter. In one case, MprA is varied keeping MprB fixed and vice versa. The MprB protein subsequently phosphorylates and dephosphorylates MprA to produce an MprA-P pool, which in turn, induces the mCherry gene through *sigE* promoter.

analyze the relation among different components of gene regulatory networks.

Future Research Plans

- Study the mechanism of sd-release in *B. subtilis* and *M. tuberculosis*
- Indentify and characterize the inhibitors of (MDR) *M. tuberculosis* transcription
- SELEX based approach to identify promoters of the sigma factors of *M. tuberculosis*

Publication(s)

- Bhawsinghka N, Dutta A, Mukhopadhyay J, Das Gupta SK (2018). A transcriptomic analysis of the mycobacteriophage D29 genome reveals the presence of novel stoperator-associated promoters in its right arm *Microbiology* ,Sep;164(9):1168-1179.

Invited Talks

- 20th Transcription Assembly Meeting, CDFD, Hyderabad 25-27 July, 2018 Direct evidence of robustness in a two-component system

Extramural Funding

Evaluating the role and mechanism of function of delta factor of Bacillus subtilis. Sciene and Engineering Research Board, Department of Science and Technology, Govt. of India, Duration: Oct 2018- 2021, Total amount: Rs 30,69,000

DR. SUMAN KUMAR BANIK

Associate Professor

Name of the Participants

Mr. Ayan Biswas, SRF; Mr. Tuhin Subhra Roy, SRF; Mr. Md Sorique Aziz Momin, JRF; Mr. Arun Kumar Das, JRF.

Collaborators

Prof. Pinaki Chaudhury, CU; Mr. Mintu Nandi, SRF, CU; Prof. Sudip Chattopadhyay, IIEST; Mr. Jagannath Das, SRF, IIEST.

Background

A living system survives in a continuously changing environment. In order to respond to the changes made in the surroundings, each living species has developed specialized gene regulatory networks (GRNs). One of the major functions of a GRN is to efficiently transduce the incoming signal. The inherent noisy interactions in the biochemical system make signal transmission stochastic and can be understood using the formalism of non-equilibrium processes.

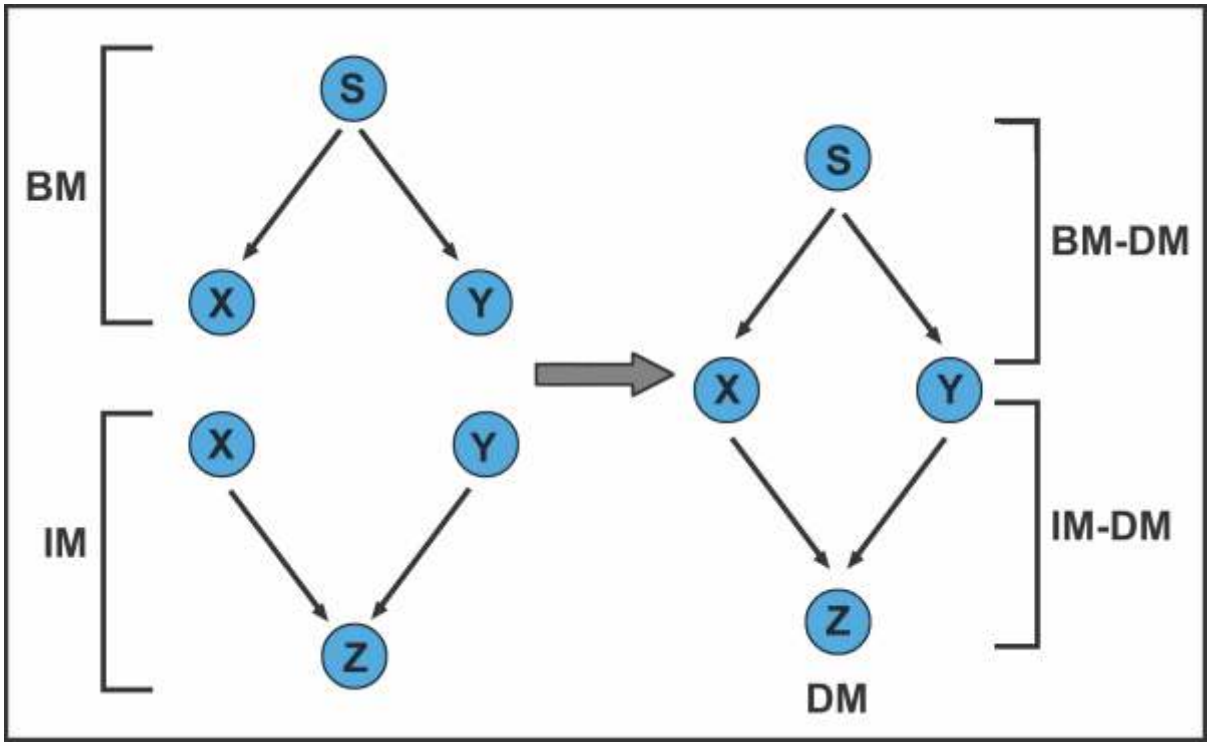
Department of Chemistry

Aims and Objectives

Our lab aims to develop theoretical frameworks to study signal transduction in GRNs using the tools of information theory. The broad focus of our research group is to understand the basis of signal transduction in biochemical networks within the purview of fluctuations in a single cell.

Work Achieved

Diamond motif (DM) is a four-node motif, found in neuronal networks of *C. elegans*, ecological food webs, and in forward logic chips embedded in electronic circuits. DM is generalized as multiple layered perceptrons found in the neural network of *C. elegans*. In DM, we have identified two sub-motifs, namely, the signal bifurcation motif (BM-DM) and the signal integration motif (IM-DM) out of the whole motif. We quantified the relative information processing strengths of the BM-DM and IM-DM operating under low, medium, and high relaxation frequency of the signal with both additive and multiplicative integration logic. Theoretical analysis reveals that signal-to-noise ratio in the DM increases with effective redundancy.



Schematic diagram of diamond motif (DM) constructed from bifurcation motif (BM) and integration motif (IM). BM-DM and IM-DM stand for the bifurcation and integration sub-motif, respectively, embedded within the diamond motif.

Future Research Plans

We aim to study information processing in other gene regulatory networks, e.g, feed-forward loop. In addition, we also plan to develop theoretical formalism in the context of information transfer in biochemical motifs.

Publications

1. Biswas A and Banik S K (2018) Interplay of synergy and redundancy in diamond motif, *Chaos* 28, 103102 [https://doi.org/10.1063/1.5044606].

2. Nandi M, Biswas A, Banik S K and Chaudhury P (2018) Information processing in a simple one-step cascade, *Phys. Rev. E* 98, 042310 [https://doi.org/10.1103/PhysRevE.98.042310].

Environmental Science Section

Introduction

Environmental sciences section was established in 1992. The research is focused to understand the different aspects of atmosphere contributing to the climate change with a special emphasis on the Eastern Himalayan climate change. The observational centres are located at Darjeeling in Eastern Himalaya along with Kolkata, Shyamnagar and Falta in the Indo-gangetic planes. ESS serves as the nodal analytical facility for the ongoing atmospheric research with the above mentioned observatories.

Faculty

Dr. Sanat K. Das, Prof. Sanjay K. Ghosh and Dr. Abhijit Chatterjee

Staff Members

Dr.Anandamay Adak, Technical Officer –I, Saral Ch. Das, Helper - E

Students/RA/Project Assistant

Sauryadeep Mukherjee, JRF, Monami Dutta, JRF, Abhinandan Ghosh, SRF, Arindam Roy, SRF, Dr. Debajyoti Ray, RA

Environmental Science Section

DR. ABHIJIT CHATTERJEE
Associate Professor

Name of the Participants

Miss Monami Dutta, JRF; Durba Das, JRF; Mr. Sauryadeep Mukherjee, JRF; Mr. Arindam Roy, SRF; Mr Abhinandan Ghosh, SRF; Dr Debajyoti Ray, RA.

Background

Aerosols, the tiny particles suspended in the atmosphere, have different sizes (diameter of nanometre to micrometer levels) and chemical compositions and variety of natural and anthropogenic (man-made) sources. Aerosols affect the earth-atmosphere radiation budget directly by scattering and absorbing the incoming solar radiation and indirectly by influencing the processes of formation of clouds and precipitation. The properties of cloud are influenced by aerosols through their role as cloud condensation nuclei, which favor condensation of water vapors on its surface and formation of cloud droplets. There are various sources of aerosols both natural and anthropogenic. The size and the chemical composition of aerosols widely vary with their sources. The source specific aerosols show different physical and chemical behavior in the atmosphere. Hence, aerosols of different sources contribute differently in the interaction with the incoming solar radiation, formation of fog/clouds, haze, as well as health effect. Therefore in-detail physical and chemical

characterization of atmospheric aerosols and their interaction with the clouds and raindrops are of paramount importance in the context of regional and global climate change.

Aims and Objectives

- Trend of aerosols at eastern Himalaya over a long-term period
- Scavenging of size-segregated aerosols by rain and its effect on nutrient deposition and rain acidity
- Impact of transported biomass burning plume on the air quality over Kolkata
- Exchange of Greenhouse Gases between biosphere and atmosphere over eastern Himalaya
- Characterization of inorganic ionic species and carbonaceous compounds in the atmosphere of tropical urban metropolis

Work Achieved

- A first-ever long-term (2009-2015) study over Himalaya shows the decreasing trends in aerosol and black carbon concentration. We explored that the changes and up gradation of the domestic fuel at the Indo Gangetic Plane regions affected the atmospheric environment over the eastern part of Himalaya

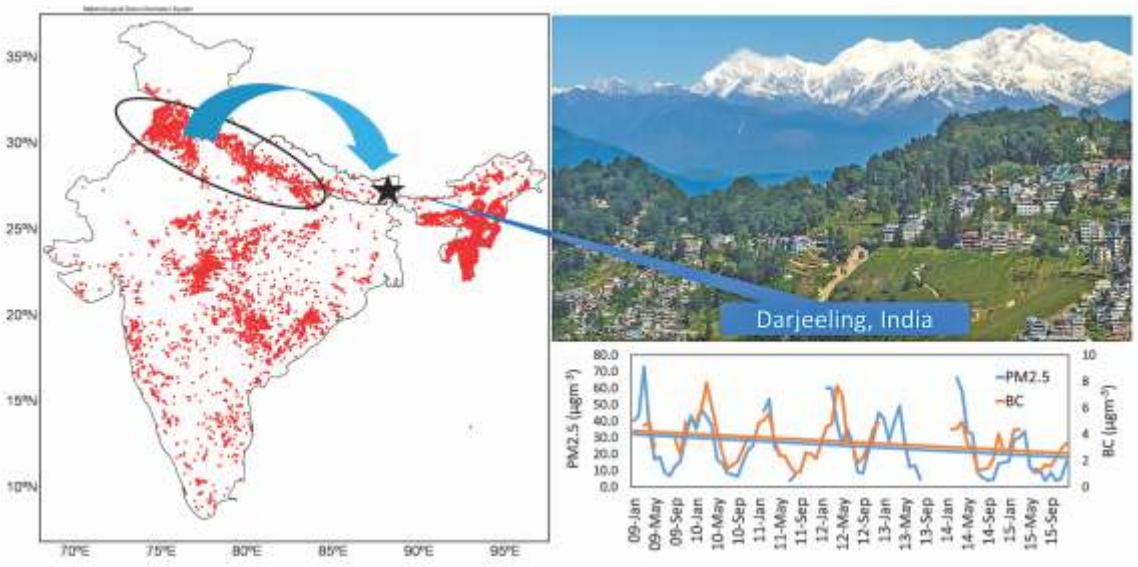


Fig 1: Long-term trend of aerosols regulated by the pollution over Indo-Gangetic Plain

- For the first time, the exchange of greenhouse gases, such as CO_2 and H_2O vapour, between the biosphere and the atmosphere at an eastern Himalayan site in India has been investigated. The net ecosystem exchange (NEE) was –656.5 g CO_2 m^{-2}, suggesting that the evergreen coniferous forest in the eastern Himalaya acts as a net sink of CO_2 during spring

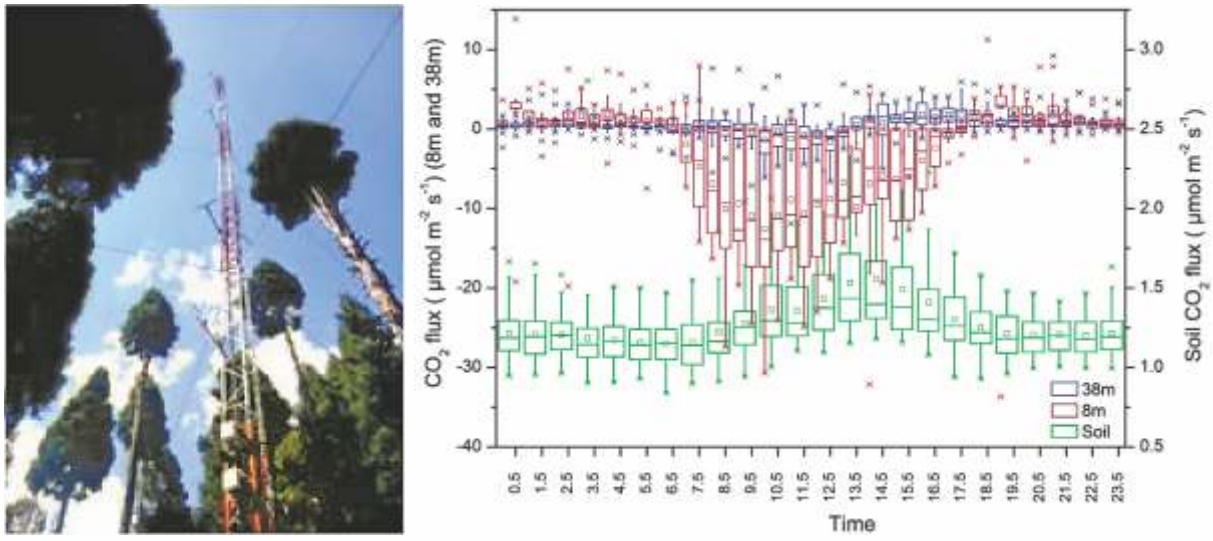


Fig 2: 50 (Left) m tall tower (Flux-tower) equipped with Eddy-Covariance system for continuous monitoring of Greenhouse Gas flux at high altitude Himalayan conifer forest at Dhotrey forest, Darjeeling; (Right) CO2 exchange between biosphere and atmosphere and soil

- A study was conducted on the impact of biomass burning plumes transported from the Eastern Ghats region on the chemical characteristics of size-segregated aerosols over Kolkata, a tropical megacity situated in the eastern part of the Indo-Gangetic Plain.

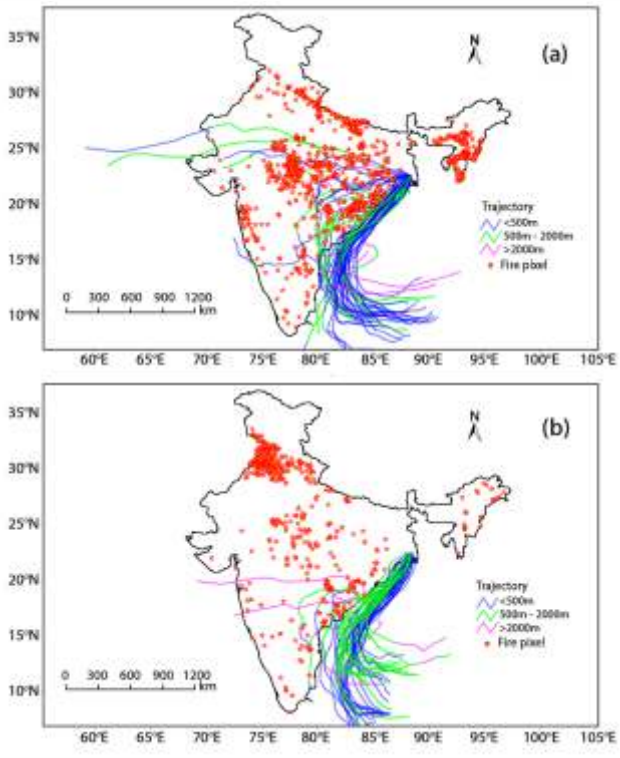


Fig 3: Biomass burning plume are transported from Eastern Ghat region to Kolkata metropolis during summer affecting air quality over Kolkata

- A long-term (2009–2018) as well as real-time observations on the below-cloud scavenging of aerosols by rain was conducted. We predicted nutrient deposition and rain acidity with excellent agreement with observed results.

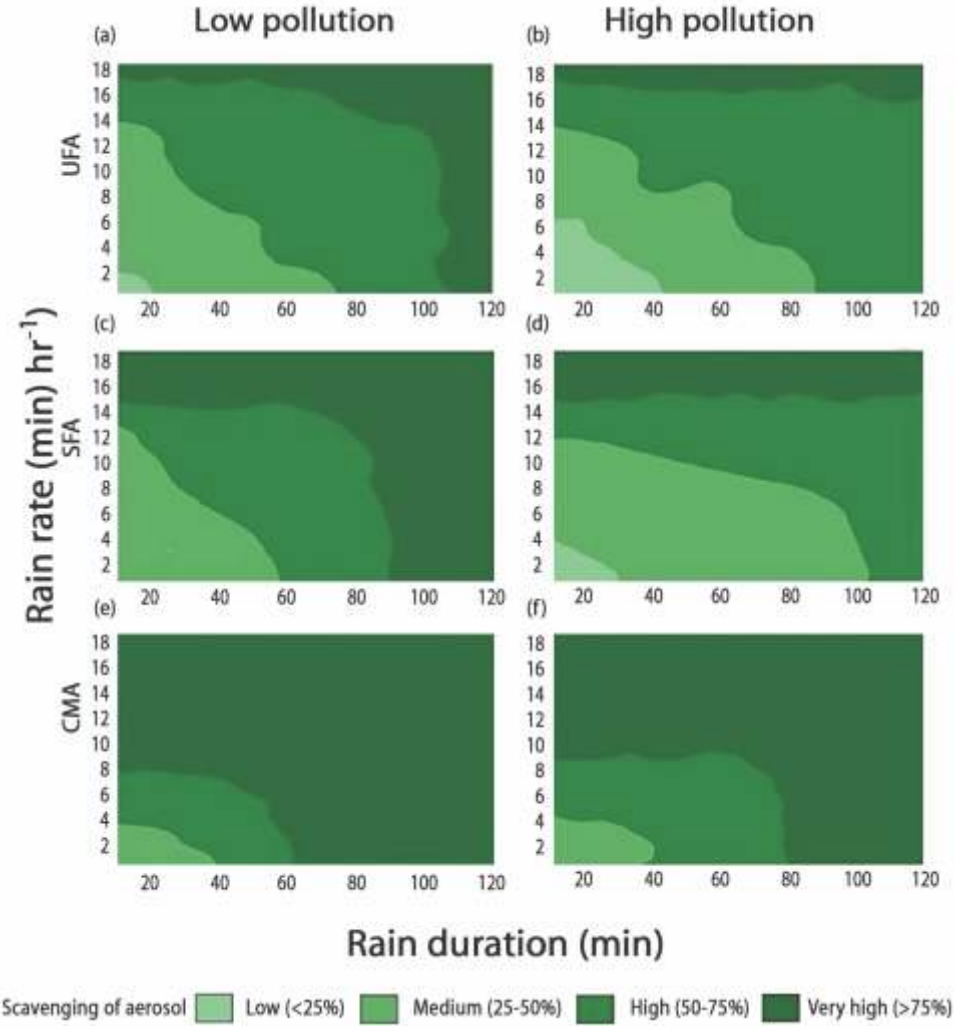


Fig 4: Scavenging of aerosols of different sizes by rain and controlled by rain duration and rain rate

Future Research Plans

- Studies on the long-term changes in air pollutants over India with the changes in socio-economic conditions.
- Studies on the aerosol induced changes in cloud microphysical properties.
- Studies on the role of organic and inorganic aerosols on the cloud droplet activation
- Studies on the effect of the atmospheric deposition of the carbonaceous aerosols on the physic-chemical characteristics of the Himalayan glaciers
- Studies on the aerosol-cloud-lightning interaction

Publications

1. Chatterjee Abhijit, Roy Arindam, Chakraborty Supriyo, Sarkar Chirantan, Singh Soumendra, Karipot Anand K, Ghosh Sanjay K, Mitra Amitabha and Raha Sibaji (2018) Biosphere Atmosphere Exchange of CO2, H2O Vapour and Energy during Spring over a High Altitude Himalayan Forest at Eastern India. Aerosol and Air Quality Research, 18.
2. Chatterjee Abhijit, Devara Panuganti C S, Balasubramanian Rajasekhar, Jaffe Daniel A (2019) Aerosol Climate Change Connection (AC3) Special Issue: An Overview. *Aerosol and Air Quality Research*, 19: 1–4, 2019
3. Ghosh Abhinandan, Roy Arindam, Chatterjee Abhijit, Das Sanat K, Ghosh Sanjay K and Raha Sibaji (2019). Impact of Transported Biomass Burning Plumes on the Size Segregated AerosolChemistry:ACase Study over aTropicalUrbanAtmosphere in Eastern India. *Aerosol and Air Quality Research*, 19,163-180.
4. Sarkar C, Roy A, Chatterjee A, Ghosh S K and Raha S (2019) Factors controlling the long-term (2009-2015) trend of PM2.5 and Black Carbon aerosols at eastern Himalaya, India. *Science of the Total Environment*, 656, 280-296.
5. Priyadharshini S Verma, Chatterjee A, Sharma S K and Mandal T K (2019) Characterization of submicron aerosol ionic and carbonaceous species over a tropical urban atmosphere at lower Indo-Gangetic Plain. *Aerosol and Air Quality research*, 19, 129- 147.
6. Ray D, Bhattacharya T S, Chatterjee A, Singha A, Ghosh S K, Raha S (2018) Hygroscopic Coating of Sulfuric Acid Shields Oxidant Attack on the Atmospheric Pollutant Benzo (a) pyrene Bound to Model Soot Particles. Scientific reports, 8(1), 129.
7. Sen A, Karapurkar S, Saxena M, Shenoy D, Chatterjee A, *et al* (2018) Stable carbon and nitrogen isotopic composition of PM10over Indo-Gangetic Plains, adjoining regions and Indo-Himalayan Range during a winter 2014 campaign. *Environmental Science and Pollution Research*, 25, 26279-26296.
8. Jain S, Sharma S, Srivastava M, Chatterjee A, Singh R, Saxena M, Mandal T K (2019). Source apportionment of PM10 over three urban atmosphere at Indo-Gangetic Plain in India: An approach using different receptor model. *Archives of Environmental Contamination and Toxicology*, 76, 114-128.

Invited Talks

- International workshop on "Air Pollution Extreme", organized by Columbia University, New York, USA and sponsored by NASA, USA held at Columbia University during 1-2 November, 2018. "Below cloud scavenging of size-segregated aerosols over eastern Himalaya in India: A long-term observation".
- International conference on "Air Pollution Monitoring" held at Mahatma Gandhi University, Kottayam, Kerala, India during 9-11 March, 2019.
- International conference on "Aerosol, Air quality and Climate Change", organized by HNB Garhwal University, Srinagar, Uttarakhand during 21-23 October, 2018

Environmental Science Section

Extramural Funding

1) Understanding the Role of Local and Transported Biogenic and anthropogen Aerosols on Microphysical and Chemical Properties o Low-level Clouds over Eastern Himalaya, India; DST, Climate Change Program; Start date: April, 2018, Amount (Rs): 7408800

2) Biosphere-Atmosphere Exchange of CO2, H2O and Energy over a High Altitude Forest Canopy at Eastern Himalaya, India; MoES; Start date: April, 2018; End date: March 2019; Amount (Rs): 2508000

Awards/Honors/Membership

- Selected as the Editor of the international peer reviewed journal, "Aerosol and Air Quality Research" (IF: 2.85)
- Selected as the Nodal Officer for the state of West Bengal for National Clean Air Program of MoEFCC, Govt of India.

Conference(s) / Workshop(s)

National: 5; International: 2

Environmental Science Section

DR. SANAT KUMAR DAS
Assistant Professor

Background

My research activities are mainly based on ground-based and space-borne observations related to aerosol-radiation-cloud-precipitation interactions, implementation of novel methodologies and measurement techniques in different atmospheric conditions (field measurements), investigation of aerosols' effects on environment and human society using different atmospheric coupling models. A research effort has been carried out to find a new method estimating water content of variety of precipitation events over complex terrain of Himalayas that are strongly influenced by mountain wind speed and atmospheric pressure. My another research activity over Antarctica identified raindrops instead of snow-flakes in the radar echoes, which could be due to radiative warming effect significantly contributed by long-range transported aerosols coming from other continental region. However, sensitivity tests are still going on in our lab. Recently we found another important result related to human health issues that winter-time fog over Indo-Gangetic Basin chokes movement of particulate matter within 2.5 micron (PM2.5) over Sundarban, venting out towards the Bay of Bengal, which indicates the deterioration of the quality of breathing air and increase of relative risk for respiratory problems and cardiac strokes over urban regions.

Aims and Objectives

1. Quantification of long-range transported elevated aerosol layer's effect on climate change processes through aerosol-cloud-precipitation interactions over the eastern Himalayas and tropical urban atmosphere
2. Investigation of human-influenced effects of aerosols on recent acceleration of glacier melting over Himalayas as well as Antarctica

3. Determination of alteration of physico-chemical properties of anthropogenic aerosols due to winter-time fog and application to now-casting and estimation of the fog-induced health effects.
4. Improvement of ocean colour algorithm by including atmospheric corrections due to different types of aerosols using measurements by ship-borne and satellite-based sensors to estimate chorolophyll concentration in coastal waters of India.
5. Simulation of extreme weather conditions like cyclones, fog, heavy rainfall using long-range observations of anthropogenic and natural aerosols to estimate their impact on human society.

Work Achieved

1. Winter-time haze worsening the *air quality* over urban regions of Indo-Gangetic Basin from 'moderate' to 'very poor' that aggravates human health risk factors .
2. Quantification of liquid water content using a *new approach* of analysis method of rain-drops size distribution for different types of precipitation over hill-top region of Eastern Himalayas.
3. Low-Altitude rainfall occurring over Eastern Antarctica is a signature of *global warming*.
4. *Evaporation of raindrops over Antarctica*: An Indication of warming effects as climate change.

Future Research Plans

1. Development of an Aerosol-optical laboratory to investigate elevated aerosol layer using ground-based Raman LIDAR measurement.
2. Balloon-borne experiment on quantification of the pollutants like ozone, particulate matter and their impact on air quality.
3. Making small sensors for measurements of air quality parameters and its impact on human health.
4. Identification of long-range transportedbioaerosols in air, raindrops and clouds using drone-based instruments and ground-based radar over Eastern India and their possible continental source regions.

Invited Talks

1. Invited talk in “Air Pollution Extremes Workshop” at Columbia University, New York during 1-2 November 2018.
2. Delivered an invited talk in “A Brainstorming Meeting” at National Atmospheric Research Laboratory (NARL), Gadanki during 18-19 December 2018.

3. Co-Convenor of the session IG09 (Interdisciplinary Sciences section), titled 'Big data, point cloud, and geospatial analytics in geosciences' in 15th Annual Meeting of Asia Oceania Geosciences Society (AOGS) during 3-8 June 2018.
4. Popular lecture during a training program for the school students on 'Indian Scientific Expedition to Antarctica' at Madhyamgram campus, Bose Institute during 18-20 Dec 2018.

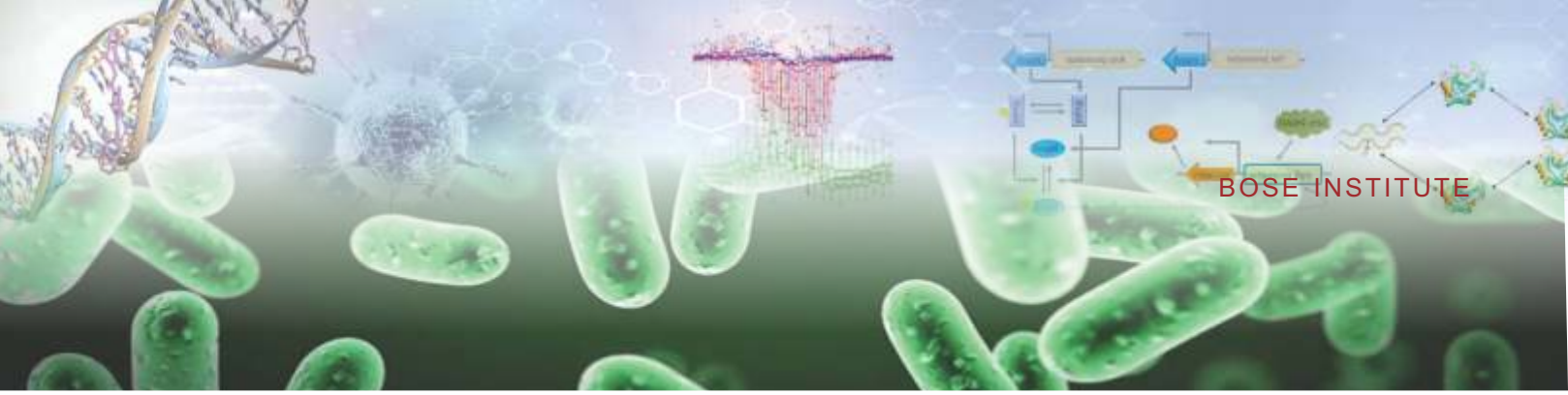
Extramural Funding

1. Ramanujan Fellowship Research Grant by DST-SERB, Govt. of India on August 2018 (Completed).
2. Project of MoEF on "Modeling carbonaceous aerosol source influence and atmospheric effects" under National Carbonaceous Aerosol Program (NCAP) as CO-PI .
3. Involved in atmospheric research works related to IRPHA-II project.
4. Project to CSIR on "Physico-chemical factors influencing Aerosol Hygroscopicity during fog, its effect on Aerosol Radiative Properties and fog now casting: a study in the context of Regional Climate Change over Eastern India" (Presently Accepted).
5. Project to MOES on "Understanding the role of 'Below Cloud Elevated Aerosol Layer' on aerosol radiative heating and Aerosol-Cloud-Precipitation interactions over tropical urban atmosphere in the Eastern India" (Under Review).

Conference(s) / Workshop(s) : Three

Publications

1. Ghosh A, Roy A, Chatterjee A, Das Sanat Kumar, Ghosh S K, Raha S (2018) Impact of Biomass Burning Plumes on the Size-Segregated Aerosol Chemistry over an Urban Atmosphere at Indo-Gangetic Plain, *Aerosol and Air quality Research*, Volume 19, Pages 163-180.
2. Roy A, Chatterjeea A, Ghosh A, Das Sanat Kumar, Ghosh S K, Raha S (2019) Below-cloud scavenging of size-segregated aerosols and its effect on rainwater acidity and nutrient deposition: A long-term (2009–2018) and real-time observation over eastern Himalaya, *Science of Total Environment*, Volume 674, Pages 223-233.



Department of Microbiology

Introduction

The Department of Microbiology, was founded in 1942 with the objective of exploring the fascinating world of microbes with particular reference to those that are environmentally, industrially and medically relevant. Currently this department is devoted to understand an assortment of microbial processes that have implications for human (pathogenesis by mycobacteria) and environmental health (xenobiotic degradation), together with those which influence, and/or are influenced by, Earth processes (geomicrobiology).The specific areas are:

- Understanding the molecular biology and metabolism of *Mycobacterium tuberculosis*, the TB pathogen, using its phages and plasmids as model systems, tools and probes.
- Molecular characterization of pathways in the metabolism of organic pollutants: Catabolic regulation, biosensor development and molecular evolution. Bioprospecting of novel molecules from gut microbiome and environmental

metagenome.

- Investigating the molecular biology and evolutionary dynamics of sulfur-chemo-lithotrophic prokaryotes, and analysis of complex microbiomes associated with extreme environments such as deep sea vents and hot springs.

Faculty

Dr. Sujoy K Das Gupta, Professor and Chairman; Dr. Tapan K Dutta, Professor and Dr. Wriddhiman Ghosh, Associate Professor.

Staff Members

Mr. Saifullah Gazi, Technical Officer – I; Mr. Prabir Kumar Haldar, Technical Officer – I; Mr. Debasish Sarkar, Office Superintendent; Mr. Rabin Pal, Helper – E; Mr. Narayan Patali, Helper - E.

Students/RA/Project Assistant

Dr. Shreya Sengupta, DST Woman Scientist; Ms. Shrestha Ghosh, SRF; Ms. Apurba Sarkar, SRF; Ms. Madhumanti Patra, SRF; Ms. Poulomi Ghosh, SRF; Mr. Anik Barman, JRF; Mr. Rahul Shaw, JRF; Rameez M J, SRF; Mr. Sabyasachi Battacharyya, SRF; Mr. Subhrangshu Mondal, SRF; Mr. Nibendu Mondal, JRF; Mr Jagannath Sardar, JRF; Dr. Madhumita Roy, DST Woman Scientist; Dr. Debarun Acharya, RA; Ms. Satamita Deb, SRF; Ms. Mousumi Bhattacharyya, SRF; Mr. Arindam Dutta, SRF; Mr. Saikat Deb, JRF; Mr. Mriganka Munshi Karmakar, JRF; Ms. Megha Chakraborty, JRF; Ms. Rinita Dhar, JRF; Mr. Suman Basu, JRF.

Ms. Satamita Deb
Winner of Prof. Shyamadas Chatterjee
Outstanding Student Award 2018
(in the area of Physical and Environmental Science)

Department of Microbiology

DR. SUJOY KUMAR DASGUPTA
Professor

List of Paticipants

Dr. Shreya Sengupta, DST Woman Scientist; Ms. Shrestha Ghosh, SRF; Ms. Apurba Sarkar, SRF; Ms. Madhumanti Patra, SRF; Ms. Poulomi Ghosh, SRF; Mr. Anik Barman, JRF; Mr. Rahul Shaw, JRF.

Background

The disease TB remains a major scourge even today although its causative agent *Mycobacterium tuberculosis* (Mtb) was discovered more than 100 years ago and several drugs for curing TB are available in the market. The main reason behind this is our poor understanding of the molecular biology of Mtb.

Bacteriophages and plasmids are autonomously replicating entities that multiply in their specific bacterial hosts. They are often used as tools to obtain deeper insight into how a bacterium's DNA is replicated and their genes expressed. We are working with a mycobacterial plasmid named pAL5000 and a mycobacteriophage named D29. We are investigating how they multiply in their Mycobacterial host by exploiting their replication and transcriptional machineries. Our expectation is that by pursuing this goal we will be able to unravel novel aspects about the basic molecular biology of mycobacteria which could be used in future drug development and TB control programs.

Aims and Objectives

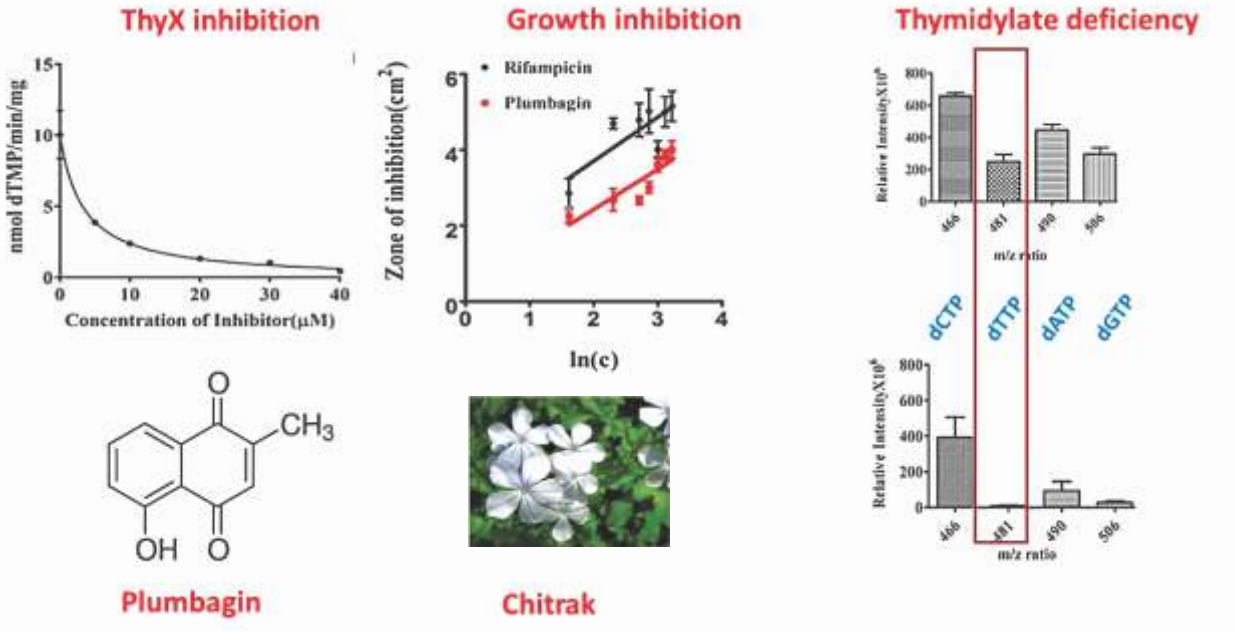
a. In the area of mycobacteriophage research our objective is to investigate the mechanism by which expression of genes belonging to the D29 genome is regulated in a temporal manner using proteomic and molecular tools.

b. Investigate how D29 phage inactivates its mycobacterial host and use the information derived for the development of drugs against TB.

c. To study mycobacterial metabolism and mechanism of initiation of cell cycle under nutrient starved and rich conditions.

Work Achieved

While investigating the molecular genetics of mycobacteriophage D29, we had demonstrated earlier that induction of thymidylate deficiency can bring about mycobacterial cell death. Based on this observation we initiated an investigation to identify small molecules, that could antagonize thymidylate synthesis in mycobacteria. Mycobacteria possess two types of thymidylate synthases, ThyA, found in all forms of life, and ThyX, found only in a subset of eubacteria many of which are deadly pathogens, *Mycobacterium tuberculosis* (Mtb) for example. ThyX has been found to be essential for the survival of mycobacteria, and therefore we chose to target it for inhibitor development. Here, we show that plumbagin (5 hydroxy 2-methyl-1, 4 naphthoquinone) a natural product derived from the medicinal plant, *Plumbago indica,* locally known as chtirak locally efficiently inhibited mycobacterial growth by bringing about thymidylate deficiency.



Plumbagin, a natural product derived from the medicinal plant Chitrak inhibits mycobacterial growth by inhibiting the enzyme ThyX and thereby inducing thymidylate deficiency in the target cells.

Future Research Plans

1. Detailed investigation into mycobacteriophage-mycobacteria interactions using metabolomics as well as proteomic tools.
2. Identification of natural products that can function as anti-mycobacterials by promoting nucleotide pool imbalance.
3. Understanding how various nutrients stimulate mycobacterial growth and/ or cell division and its implication in the area of anti-TB drug development.

Students Awarded Ph.D.

Niketa Bhawsinghkha (CU, 2018) Transcriptomic Analysis of Mycobacteriophage D29 Infection.

Publications

1. Bhawsinghka N, Dutta A, Mukhopadhyay J, Das Gupta S K (2018) A transcriptomic analysis of the mycobacteriophage D29 genome reveals the presence of novel stoperator-associated promoters in its right arm, *Microbiology*, 164(9):1168-79.
2. Roy Madhurima, Kundu Anirban, Bhunia Anirban, Das Gupta Sujoy, De Soumya, Das Amit Kumar (2019) Structural characterization of VapB46 antitoxin from *Mycobacterium tuberculosis*: insights into VapB46–DNA binding**,** *The FEBS Journal*. 286: 1174-1190

Invited Talk

1. Delivered an invited lecture entitled "Reconnecting with our viral ancestors" at the MoEFCC and SERB sponsored workshop on "Genomics for Microbial Diversity and Taxonomy" (GEMTAX- 2019), organized by Department of Life Science, NIT Rourkela, Odisha held from 21-25 January, 2019.

Extramural Funding

DST – SERB sponsored project: Phage inspired antibiotics for mycobacteria (21.03.2018 to 20.03.2021)

Conference(s) / Workshop(s)

Participated and presented a paper on "Mycobacteriophage based platforms to discover drug targets for mycobacteria" at the "5th World Congress on Targeting Infectious Diseases: Targeting Phage and Antibiotic Resistance 2018" held at Florence Italy (May 17-18, 2018).

DR. TAPAN K. DUTTA

Professor

Name of the Participants

Rinita Dhar, JRF; Suman Basu, JRF; Mriganka Munshi Karmakar, JRF; Megha Chakraborty, JRF; Mousumi Bhattacharyya, SRF; Satamita Deb, SRF; Arindam Dutta, SRF; Dr. Debarun Acharya, RA; Dr. Madhumita Roy, RA (DST-WOSA).

Collaborators

Kannan Pakshirajan, Professor, IIT- Guwahati; Tapas K. Sengupta, Professor, IISER- Kolkata; Subrata K. Das, Scientist F, ILS, Bhubaneswar; Darren Reynolds, Professor, University of West England, Bristol, UK; Robin Thorn, Lecturer, University of West England, Bristol, UK.

Background

Human greed has been manifested changes in lifestyle at the expense of massive environmental insult due to release of thousands of health hazard man-made chemicals into the ecosystem. Due to catabolic robustness and evolutionary plasticity, exploration of bacterial potential in the management of environmental pollutants is one of the most significant and sustainable areas in contemporary research.

Thus, congregate substantial knowledge on microbiological processes regarding biomolecular evolution, regulation, and potentiality to remediate the

deleterious effects of anthropogenic activities and biosensor-based monitoring on environment are important to understand these key areas in this field of research.

Further to comprehend the exceptional ecology and torrents of possibilities that lies in the distinct microbial niches, it is important to emerge with sustainable schemes for the betterment of humanity and also to understand host-pathogen relationships in a deeper way with a possible development of contemporary therapeutic strategies.

Aims and Objectives

- Metabolism of estrogenic and carcinogenic environmental organic pollutants.
- Molecular characterization of catabolic genes and regulatory elements to understand regulation of degradative pathways
- Development of chromosome- and/or plasmid-based bioreporter strains to monitor environmental pollutants
- Gut microbiome and metagenomics analysis: Functional characterization of novel enzymes and biosynthetic pathways based on fosmid or BAC cloning and *in-silico* analysis of deep sequencing data of whole gut microbiome or metagenomic DNA
- Bio-prospecting study of novel anti-microbials from plant, fish and microbes.
- Co-evolution of residues during functional evolution of enzyme system by bioinformatics followed by experimental validation
- *In silico* analysis of human-bacteria protein-protein interaction network for a better understanding of pathogenicity and drug design

Work Achieved

For the development of biosensor that can detect Endocrine Disrupting Chemicals (EDCs), a number of EDC-degrading bacteria have been isolated based on its utilization as sole carbon source followed by characterization of associated biochemical pathways and induction profile of the degradative pathways. In another approach, bacterial management of toxic cyano aromatics (2-, 3-, and 4-hydroxybenzonitrile) has been studied to characterize the catabolic gene cluster and the possible crosstalk among the concerned metabolic pathways in a catabolically versatile *Burkholderia* sp. strain BC1.

While dealing with the 2NBA-inducible *onb* catabolic gene cluster (*onbX1X2FCAR1EHJIGDBX3R2*) in *Cupriavidus* sp. strain ST-14, a putative MFS type transporter protein OnbX2 carrying 12 -helix transmembrane spanners has been identified. Deletion of this gene resulted in delayed uptake of 2NBA by the X2 mutant cells resulting in slow growth rate in presence of 2NBA. Additionally, this protein plays a role in 2NBA chemotaxis. Furthermore, to confirm membrane localization, OnbX2 was expressed in *E. coli* C43 (DE3) cells in form of GFP tagged fusion protein. Confocal microscopy images (Fig. 1) showed that unlike the free GFP which showed a cytoplasmic diffused pattern, GFP tagged with OnbX2 localizes at the cell periphery confirming membrane compartmentalization of the target protein.

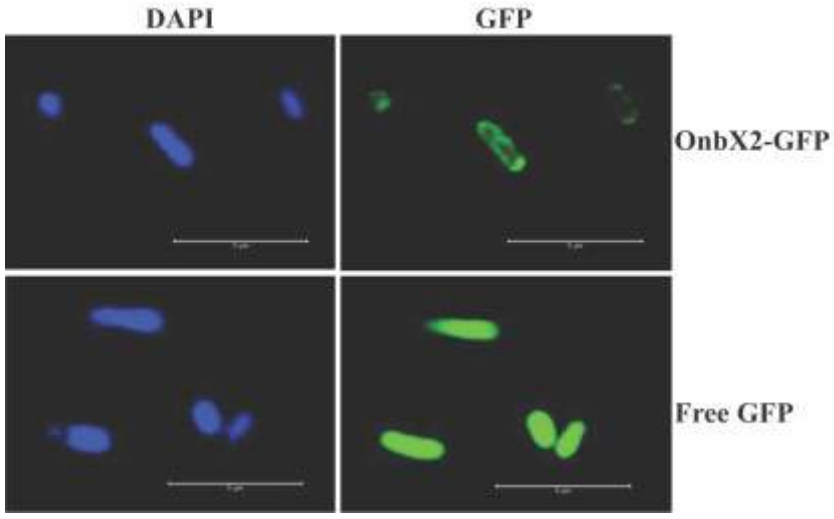


Fig. 1. Confocal microscopy images of *E. coli* C43 (DE3) cells expressing free GFP and OnbX2 tagged GFP fusion proteins. Bacterial chromosomes have been visualized with DAPI staining.

The molecular basis of the differential activity of naphthalene dioxygenase (NDO) and different nitroarene dioxygenases (NArDO) was investigated using simulation of two enzyme systems followed by biotransformation study of different mutant forms of NDO. Therefore, to get a mechanistic insight into the molecular basis of differential conformational dynamics comparison of the Residual Interaction Network (RIN) of two enzyme systems was carried out (Fig. 2).

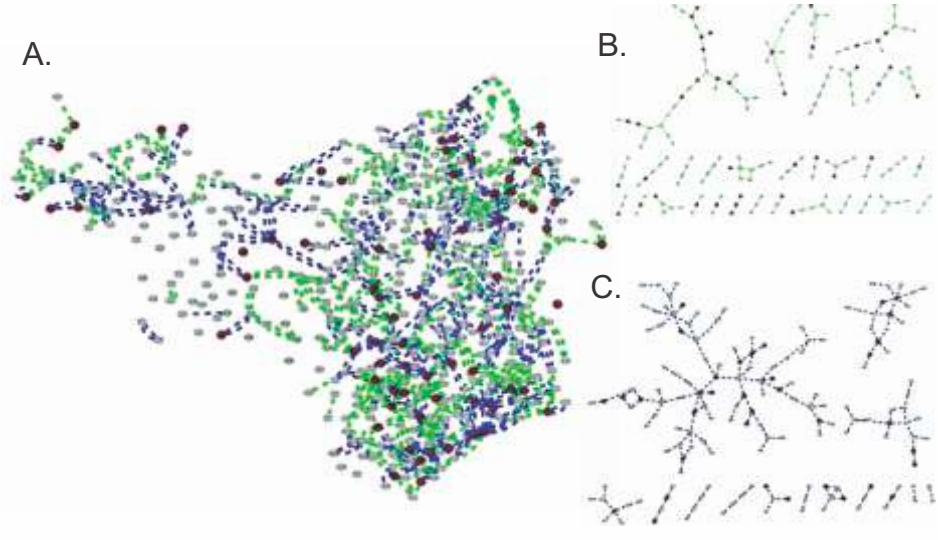


Fig. 2. Outputs of RIN analysis **A**. Unique interactions of NDO and NArDO are colored Green and Blue respectively. **B**. Networks of unique interactions present in NDO. **C**. Networks of unique interactions present in NArDO

Other studies include culturable and non-culturable microbial diversity analysis of Hilsa (*Tenualosa ilisha*, an anadromous fish), functional characterization of various important enzymes and/or biosynthetic pathways of antimicrobial compounds/peptides from plant, fish and microbes.

In another endeavor, to understand the molecular basis of bacterial diseases (*Bacillus anthracis*, *Francisella tularensis* and *Yersinia pestis*, all of which falls under category A bioterrorism agents) and identification of candidate proteins as possible therapeutic targets, attempts have been made to explore the high-throughput human-bacteria protein interaction network dataset.

Future Research Plans

- Characterization of catabolic genes and regulatory elements to understand regulation of inducible operon(s) of degradative pathways of health hazard pollutants.
- Development of chromosome- and/or plasmid-based bioreporter strains to monitor environmental pollutant.
- To study novel antimicrobials and other bioactive compounds together with polyketide synthase gene clusters for non peptidal polyketide antibiotics from mangrove plant and its associated microbes (root/shoot/leave endophytes and root rhizosphere) with a special emphasis on the genera *Bacillus*, *Actinomycetes*, and *Pseudomonas*.
- Exploring the host-pathogen interaction by *in silico* analysis of human-bacteria protein-protein interaction network for a better understanding of pathogenicity and drug design.

Publications

1. Deb S, Basu S, Singha A, Dutta T K (2018) Development of a 2-nitrobenzoate-sensing bioreporter based on an inducible gene cluster. *Front. Microbiol*. 9, 254.
2. Basu S, Deb S, Pal Chowdhury P, Dutta T K (2018) Diverse catabolic pathways in the degradation of phenylalkanoic acids and their monohydroxylated derivatives in *Cupriavidus* sp. Strain ST-14. *Process Biochem*. 75, 221-229.

Extramural Funding

Hydrogenogenic carbon monoxide conversion under mesophilic condition using anaerobic granular sludge for biodesulphurization, DBT-NER Twinning Programme.

The development and implementation of sensors and treatment technologies for freshwater systems in India, DST Technology Mission Division sponsored Indo-UK project.

Conference(s) / Workshop(s)

Under the ongoing Indo-UK project, a symposium on water quality research was organized entitled "Challenges for the freshwater systems: Sensors and treatment technologies" on 07-02-2019 at Bose Institute, participated by more than hundred scientists / researchers / NGOs working in the related field including our UK collaborators.

DR. WRIDDHIMAN GHOSH

Associate Professor

Name of the Participants

Nibendu Mondal, JRF; Jagannath Sarkar, JRF; Moidu Jameela Rameez, SRF; Sabyasachi Bhattacharya, SRF; Subhrangshu Mandal, SRF.

Collaborators

Prof. Ranadhir Chakraborty, Department of Biotechnology, University of North Bengal, Siliguri, West Bengal - 734013, India; Dr. Aninda Mazumdar, Gas Hydrate Research Group, Geological Oceanography, CSIR-National Institute of Oceanography, Dona Paula, Goa - 403004, India; Dr. John Edward Hallsworth, Institute for Global Food Security, School of Biological Sciences, MBC, Queen's University Belfast, Belfast, BT9 7BL, Northern Ireland.

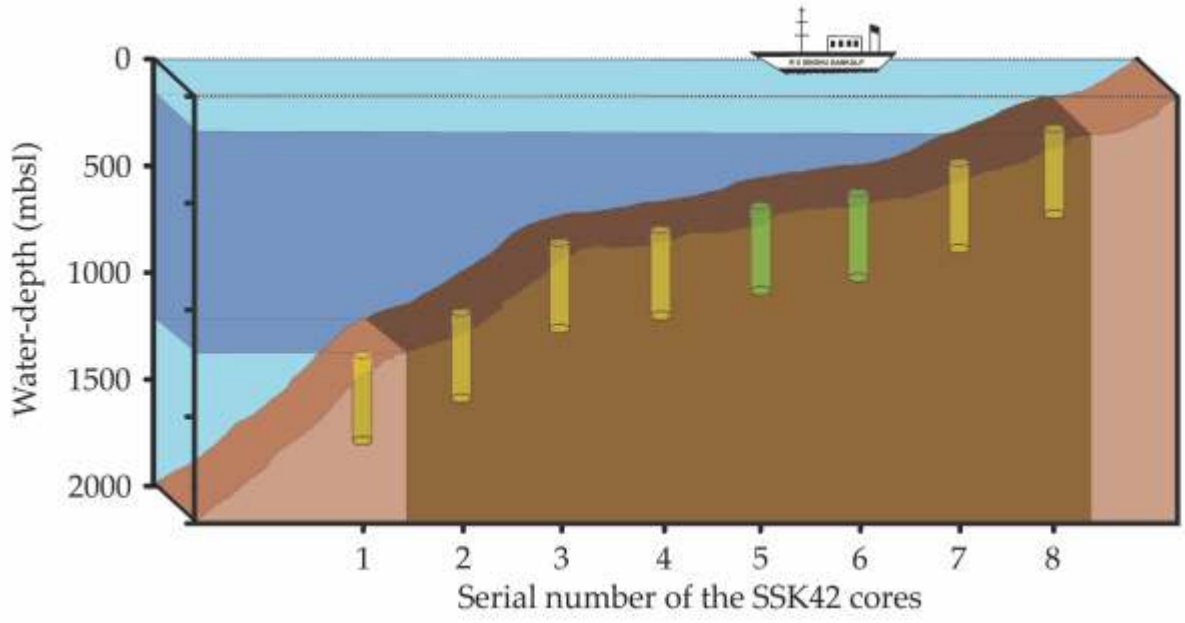
Background

Geomicrobial dynamics of the marine oxygen minimum zones (OMZs) have profound influence on oceanic biodiversity, productivity and fixed-nitrogen loss[1]. For the OMZs distributed across the global ocean, microbial community architectures of their anoxic sediments are less explored as compared to those of the hypoxic waters. Whereas the water-columns of OMZs

afford pM-nM O_2, which is reportedly sufficient for successful maintenance of aerobic lifestyle, their sediments have extremely shallow O_2-penetration depth due to high flux of labile organic matter across the sea-bed leading to rapid consumption of O_2. As physicochemical considerations ruled out influx of O_2 from the water column below a few centimeters of OMZ sea-floors, potential ecology of aerobic microorganisms was never investigated in these anoxic sediments, despite the fact that plausible aerobic activities can have significant effects on the catabolic breakdown (remineralization) of the copious, labile organic matters that are sequestered in the sediments underlying hypoxic marine waters.

Aims and Objectives

Across the sediment-horizons of Arabian Sea, which harbors the thickest and one of the most intensely hypoxic marine OMZ, maximum depth of O_2 penetration reported is 1.6 centimeters below the sea floor (cmbsf). Our group, on-board *RV* Sindhu Sankalp (SSK42), explored two ~3-m-long gravity-cores (at 15-30 cm resolutions) from the sulfidic/anoxic sediments underlying the center of the vertical-expanse of the eastern Arabian Sea OMZ (ASOMZ). The two cores, SSK42/5 and SSK42/6 located at 580 and 530 meters below the sea-level (mbsl) respectively, were



Schematic diagram showing the locations of the sediment cores SSK42/5 and SSK42/6, in the context of the ASOMZ and the other SSK42 cores studied from this region previously (Fernandes et al., 2018). Water-depth is plotted in scale along the vertical axis, while distances between the cores represented along the horizontal axis are not in scale. The OMZ is indicated by blue-gray shade; both the upper and lower oxyclines are indicated by light turquoise; sediments horizons underlying the different water-zones are indicated by different shades of brown.

investigated for the potential ecology of aerobic bacteria. A "geochemistry - metagenomics – pure/mixed culture characterization – genomics - metatranscriptomics" approach was used to investigate the microbiome structure/function in this sediment-horizon, where high concentrations of pore-water H_2S preclude the presence/influx of free O_2.

Work Achieved

Aerobic microbial communities were revealed along two, ~3-meter-long sediment-cores underlying the heart of the eastern ASOMZ, where high H_2S disallows O_2 influx from the water-column. Genes for aerobic respiration by *aa*$_3$-/*cbb*$_3$-type cytochrome-*c* oxidases and cytochrome-*bd* ubiquinol oxidase, aerobic oxidation of methane/ammonia/alcohols and thiosulfate/sulfite/organosulfur-compounds, are all abundant *in situ*. Live aerobic, sulfur-chemolithoautotrophs and chemoorganoheterotrophs are also abundant here. The 8820-years-old, highly–sulfidic, methane-containing sediment-sample from 275 cmbsf of 530 mbsl yielded many aerobic bacterial isolates that died upon anaerobic incubation with alternative electron-acceptors/fermentative-substrates. Mapping of metatranscriptomic reads from this sediment-sample onto aerobic-respiration-related genes from the *de novo* sequenced genomes of the obligately-aerobic isolates confirmed their aerobic lifestyle *in situ*. Metagenomic and metatranscriptomic detection of perchlorate-/chlorate-respiration genes, together with co-culture-based data, indicated that cryptic O_2 produced by perchlorate-respirers could be a potent mechanism sustaining aerobic life in this environment.

Future Research Plans

The immediate aim is to unravel the plausible molecular mechanisms which sustain aerobic microbial life in anoxic habitats, while the global aim is to delineate the biogeochemical significance of this. Biogeochemical significance, here, is a collective term denoting the sum total of the contributions of

a) aerobic chemoorganohetertrophs in carbon remineralization,

b) aerobic chemolithoautotrophs in mobilization of sulfur, nitrogen, iron, and other metals/metalloids, and

c) aerobic chemolithoheterotrophs in tandem cycling of organic and inorganic nutrients, in the system.

Aerobic life amidst anoxia could be a hugely significant Earth process because anoxic environments are giant sinks of organic carbon, and reduced metal ion, sequestration, and in being so play profound roles in abating global warming (notably, anaerobic metabolisms depend mostly on simple carbon compounds and cannot degrade complex organic matter, while most chemolithotrophs known thus far also do not respire anaerobically).

Department of Microbiology

Students Awarded Ph.D.

Prosenjit Pyne (CU, 2019) Molecular Basis of Tetrationate Oxidation by Chemolithotrophic Bacteria.

Publications

1. Saha T, Ranjan V K, Ganguli S, Thakur S, Chakraborty B, Barman P, Ghosh W and Chakraborty R (2019) *Pradoshia eiseniae* gen. nov., sp. nov., a spore-forming member of the family Bacillaceae capable of assimilating 3-nitropropionic acid, isolated from the anterior gut of the earthworm *Eisenia fetida*. *International Journal of Systematic and Evolutionary Microbiology* 69, 1265-1273.
2. Roy C, Bakshi U, Rameez M J, Mandal S, Haldar P K, Pyne P and Ghosh W (2019) Phylogenomics of an uncultivated, aerobic and thermophilic, photoheterotrophic member of *Chlorobia* sheds light into the evolution of the phylum *Chlorobi*. *Computational Biology and Chemistry* 80, 206-216.
3. Lee C J, McMullan P E, O'kane C J, Stevenson A, Santos I C, Roy C, Ghosh W, Mancinelli R L, Mormile M R, McMullan G and Banciu H L (2018) NaCl-saturated brines are thermodynamically moderate, rather than extreme, microbial habitats. *FEMS Microbiology Reviews* 42, 672-693.
4. Pyne P, Alam M, Rameez M J, Mandal S, Sar A, Mondal N, Debnath U, Mathew B, Misra A K, Mandal A K and Ghosh W (2018) Homologs from sulfur oxidation (Sox) and methanol dehydrogenation (Xox) enzyme systems collaborate to give rise to a novel pathway of chemolithotrophic tetrathionate oxidation. *Molecular Microbiology* 109, 169-191.
5. Fernandes S, Mazumdar A, Bhattacharya S, Peketi A, Mapder T, Roy R, Carvalho M A, Roy C, Mahalakshmi P, Silva R, Rao P S, Banik S K and Ghosh W (2018) Enhanced carbon-sulfur cycling in the sediments of Arabian Sea oxygen minimum zone center. *Scientific Reports* 8, 8665.

Invited Talk

Delivered a series of invited lectures at the Department of Molecular and Cell Biology, University of Connecticut, Storrs, CT, USA, between 20 August and 23 August 2018.

Extramural Funding

Quest for the biophysical basis of habitability of hydrothermal vent ecosystems (SERB) 23.03.2017 to 22.03.2020.

Awards / Honours / Memberships

One year honorary membership awarded by Geochemical Society, USA.

Conference(s) / Workshop(s)

Bhattacharya S, Mapder T, Roy C, Rameez M, Berchmans S, Peketi A, Mazumdar A and Ghosh W. (2018) Cryptic Methane Cycle in the Upper Sediment Layers of the Arabian Sea Oxygen Minimum Zone. Goldschmidt Conference 2018 Boston, MA, USA (Organizers: European Association of Geochemistry and the Geochemical Society USA).

Also Co-convened and Co-chaired the session 10b titled Biogeochemical Cycling in Aquatic Sediments: Mechanisms, Environmental Controls and Responses to Change in Goldschmidt Conference 2018, Boston, USA.

Division of Molecular Medicine

Introduction

The primary mission of this Division is to understand the molecular architecture of different cellular functions related to vital life processes, and also to unravel the complexities of a disease process. To achieve this, multidirectional approaches have been initiated by various faculties of this Division to understand the fundamental aspects of cancer, protein mis-folding-related neuro-degenerative disorders and pathophysiology of diseases both at the cellular and molecular levels, as well as to identify and manipulate targets using immunotherapy, natural products, repurposed drugs, synthetic molecules, nanoparticle-mediated drug and gene delivery. The key basic areas of research are Cancer, Immunotherapy of cancer Cell Growth and Proliferation, Neuro-degenerative Disorders, Patho-physiology of Diseases, Chemical Biology, Translational Animal Research. Cutting edge basic research will generate knowledge and

provide original insights into biological processes vital for normal cellular function, as well as translate this knowledge into understanding the molecular mechanisms of a disease process. This will in turn result in high quality publications with high scientific impact and global visibility. In-depth understanding of vital cellular processes and their perturbations in causing a disease will open up new avenues to strategize novel therapeutic approaches towards blocking a disease process. Identification of bioactive natural as well as synthetic molecules and repurposing of drugs may provide novel therapeutic leads, which may result in national as well as international patents.

Faculty

Dr. Gaurisankar Sa, Professor and Chairman; Dr. Subrata Majumder, Professor; Dr. Paramesh C. Sil, Professor; Dr. Tanya Das (Dean, R&D), Professor; Dr. Nripendranath Mandal (Superannuated on 31-01-2019), Professor; Dr. Anup K Mishra, Professor; Dr. Mahadeb Pal, Professor; Dr. Atin K Mandal, Associate Professor; Dr. Kaushik Biswas, Associate Professor; Dr. Kuladip Jana, Senior Scientist.

Staff Members

Mr. Prabal Gupta, Technical Officer II; Mr. Uttam Kr Ghosh, Technical Officer I; Mr. Arindam Basu, Technical Officer I; Mr. Debasish Majumder, Technical Officer I; Dr. Nilanjana Bhattacharya, Office Superintendent; Ms. Sanghamitra Das, Senior Lab Assistant; Mr. Sourav Samanta, Senior Lab Assistant; Mr. Kalyan Das, Upper Division Clerk; Mr. Amartya Sen, Helper-E; Mr. Ranjit Das, Helper-D; Mr. Sankar Prasad Bari, Helper-D; Mr. Purnendu Manna, Helper-D; Mr. Bijoy Munsi, Helper-G.

Students/RA/Project Assistant

Abhisek Sarkar, SRF (UGC-Adhoc); Abhishek Kumar Das, JRF; Abhishek Dutta, JRF/SRF; Ananya Dutta, JRF/SRF; Anirban Manna, SRF; Ankita Mandal, JRF; Ansupriya Si, JRF/SRF; Aparajita Das, JRF/SRF; Apoorva Bhattacharya, JRF/SRF; Apratim Dutta, JRF/SRF; Arin Guchhait, CSIR-SRF; Arnab Karmakar, JRF/SRF; Asif Ali, JRF/SRF; Baijayanti Ghose, SRF; Barun Mahata, JRF/SRF; Chirantan Majumdar, SRF; Debanjana Mitra, JRF/SRF; Dia Roy, SRF; Dr. Aharna Guin, RA; Dr. Arijit Bhowmik, RA; Dr. Ayan Mandal, RA; Dr. Debjyoti Paul, RA; Dr. Deblina Guha, RA; Dr. Debomita Sengupta, RA; Dr. Dipanwita Mukherjee, RA; Dr. Kabirul Islam, RA-NPDF; Dr. Manjari Kundu, RA; Dr. Nivedita Roy, RA; Dr. Papri Basak, RA; Dr. Poulami Khan, RA; Dr. Prasanta Saini, Dr. Ranjita Das, RA; Dr. Rishila Ghosh, RA; Dr. Sarita Sarkar, RA; Dr. Shravanti Mukherjee, RA; Dr. Soumita Mukherjee, SERB-NPDF; Dr. Subir K. Juin, RA; Dr. Suchandra Majumdar, RA; Dr. Supriya Chakraborty, RA; Dr. Swatilekha Ghosh, RA; Dr. Utsab Debnath, RA-NPDF; Dr. Ranjita Das, Women Scientist; Suman Mukherjee, JRF/SRF; Dwaipayan Chakraborty, SRF; Elora Khamrui, JRF (CSIR Adhoc); Hossainoor Rahman Sareng, JRF; Ishani Bhaumik, CSIR-SRF; Junaid Jibran Jawad,

Division of Molecular Medicine

JRF/SRF; Madhuparna Chakraborty, JRF; Monalisa Kundu, CSIR-SRF; Mousumi Kundu, SRF; Naibedya Dutta, SRF; Noyel Ghosh, JRF; Poulami Sarkar, JRF/SRF; Pradip Shit, CSIR-JRF; Pramit Bhattacharjee, SRF; Pritam Sadhukhan, JRF/SRF; Saikat Dutta, JRF; Samhita De, SRF; Sarmistha Banerjee, JRF/SRF; Satyajit Haldar, JRF/SRF; Sayanta Dutta, SRF; Sayantan Bose, SRF; Shendge Anil Khushalrao, JRF/SRF; Shabina Parveen, JRF/SRF; Sharmistha Chatterjee, SRF; Shibjyoti Debnath, SRF (UGC Adhoc); Shruti Banerjee, JRF/SRF; Somesh Roy, JRF; Sounak Banerjee, JRF (UGC Adhoc); Sourav Panja, SRF Institute Fellow; Sourio Chakraborty, JRF/SRF; Subha Roy, JRF (UGC Adhoc); Subhadip Pati, SRF; Subhanki Dhar, SRF; Sukanya Saha, JRF/SRF; Sumit Ghosh, SRF; Sushweta Mahalanobish, SRF; Suvranil Ghosh, SRF; Swastika Paul, JRF/SRF; Sweta Ghosh, JRF/SRF; Tania Sarkar, SRF; Tapasi Manna, UGC-SRF; Tapasree Basu Mallik, Adhoc UGC Fellow, SRF; Uday Hossain, JRF; Udit Basak, JRF/SRF; Nilanjan Gayen, SRF; Dhiman Saha, JRF; Suman Mukherjee, JFR; Dr. (Mrs.) Dipanwita Chakraborty, DBT RA; Debabrata Mondal, DST Inspire Fellow (SRF); Anil Khushalrao Shendge, Adhoc CSRIR SRF; Sayanta Sakar, JRF; Sharmistha Chatterjee, JRF.

DR. ANUP KUMAR MISRA

Professor

Name of the Participants

Ms. Ishani Bhaumik, CSIR-SRF; Mr. Arin Gucchait, CSIR-SRF; Ms. Tapasi Manna, UGC-SRF; Ms. Monalisa Kundu, CSIR-SRF; Mr. Pradip Shit, CSIR-JRF; Dr. Kobirul Islam, NPDF; Dr. Utsab Debnath, NPDF; Mr. Debashis Mazumder, Technical Officer-I.

Background

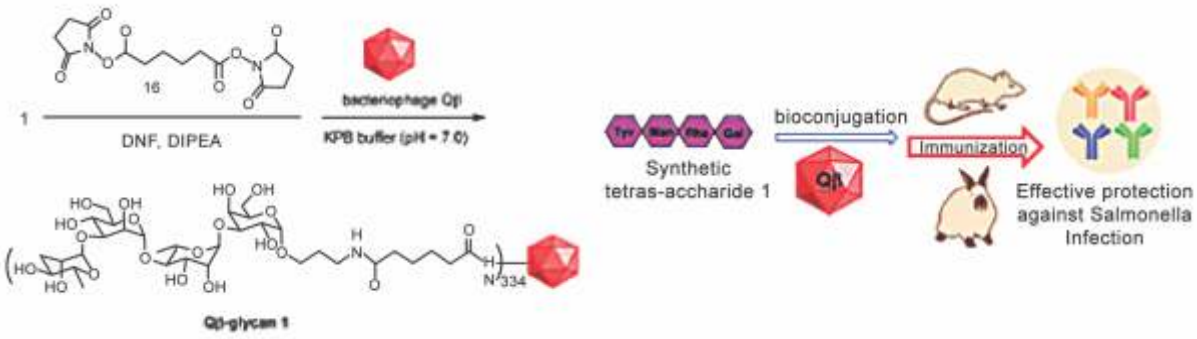
Development in the glycobiology research amplified the demands for well-defined oligosaccharide motifs for various biological studies. Naturally derived bacterial capsular polysaccharides have been the basis for effective anti-bacterial vaccines, but little is known about the protective glycotopes for many serotypes. Since natural source cannot provide the large quantity of oligosaccharides with homogeneity and adequate purity, it is essential to develop chemical synthetic approaches for getting access to the complex oligosaccharides. Stereoselective glycosylation reaction is the key component for assembling of monosaccharides towards the synthesis of complex oligosaccharides. Cell wall oligosaccharides corresponding to the repeating units and sub-units of polysaccharides, differing in chain length and monosaccharide composition help to identify antigenic determinants for the creation of semi-synthetic glycoconjugate vaccine candidates.

Division of Molecular Medicine

Aims and Objectives

- Development of novel reaction methodologies for the stereoselective chemical glycosylations.
- Conjugation of oligosaccharides with suitable proteins to form glycoconjugates and their evaluation for possible antibacterial vaccine candidates.
- To develop natural products inspired small molecules having pharmaceutical potential.

Work Achieved



- Stereoselective synthesis of a series of complex oligosaccharides corresponding to the pathogenic bacterial cell wall polysaccharides.
- Preparation of a number of glycoconjugate derivatives and their immunochemical studies towards the development of vaccine leads against *Salmonella* and *meningococcal* infections.
- Design and synthesis of natural products inspired small molecules having anti-cancer, anti-filarial and anti-inflammatory activities.

Future Research Plans

- Unveiling the untold mysteries of stereoselective chemical glycosylations.
- Extending the immunological studies of the glycoconjugate derivatives using animal models.
- Development of novel reaction methodologies relevant to the synthetic organic chemistry.
- Synthesis and biological evaluation of sugar conjugated natural products.

Students Awarded Ph.D.

- Anshupriya Si (CU, 2018) Synthetic studies on polysaccharide fragments of microbial origin.

Publications

1. Gucchait Arin, Misra Anup Kumar (2019) Influence of remote functional groups towards the formation of 1,2-*cis* glycosides: special emphasis on -mannosylation, *Org. Biomol. Chem.* 17, 4605-4610.
2. Huo Chang-Xin, Dhara Debashis, Baliban Scott M, Nick Setare Tahmasebi, Tan Zibin, Simon Raphael, Misra Anup Kumar and Huang Xuefei (2019) Synthetic and immunological studies of *Salmonella* Enteritidis O-antigen tetrasaccharides as potential anti-*Salmonella* vaccines.. *Chem Commun* . 55, 4519-22.
3. Bhaumik Ishani, Pal Kunal, Debnath Utsab, Karmakar Parimal, Jana Kuladip, Misra Anup Kumar (2019) Natural product inspired allicin analogs as novel anti-cancer agents. *Bioorganic Chemistry;* 86, 259-272.
4. Gucchait Arin, Ghosh Angana and Misra Anup Kumar (2019) Convergent synthesis of the pentasaccharide repeating unit of the biofilms produced by *Klebsiella pneumoniae*. *Beilstein J. Org. Chem.* 15, 431-436
5. Shit Pradip, Misra Anup Kumar (2019) Synthesis of a hexasaccharide repeating unit of the cell wall polysaccharide of *Bifidobacterium animalis* subsp. *lactis* LKM512. *Carbohydrate Research,* 473, 12-17.
6. Manna Tapasi, Misra Anup Kumar (2018) Aqueous medium preparation of dialkyl diselenides. *SynOpen*, 02, 229-233.
7. Parida Pravat Kumar, Mahata Barun, Santra Abhisek, Chakraborty Sohini, Ghosh Zhumur, Raha Sanghamitra, Misra Anup Kumar, Biswas Kaushik, Jana Kuladip (2018) Inhibition of cancer progression by a novel trans-stilbene derivative through disruption of microtubule dynamics, driving G2/M arrest, and p53-dependent apoptosis. *Cell death & disease,* 9, 448.
8. Pyne P, Alam M, Rameez M J, Mandal S, Sar A, Mondal N, Debnath U, Mathew B, Misra Anup K, Mandal A K, Ghosh W (2018) Homologs from sulfur oxidation (Sox) and methanol dehydrogenation (Xox) enzyme systems collaborate to give rise to a novel pathway of chemolithotrophic tetrathionate oxidation. *Molecular Microbiology. doi.org/10.1111/mmi.13972.*

Extramural Funding

i. DST SERB Project: Synthesis of polysaccharide fragments of *Streptococcus pneumoniae* strains for the preparation of glycoconjugate derivatives (SERB Sanction No. EMR/2015/000282, dated September 17, 2015); Date of start: October 09, 2015; Date of completion: October 08, 2018; Total cost of the project: Rs. 16,90,000/-.

ii. CSIR Project: Synthesis of oligosaccharide fragments corresponding to *Salmonella* strains and their use in the preparation of glycoconjugate derivatives, [Sanction No. 02(0237)/15/EMR-II, dated 26.11.2015]; Date of start: January 01, 2016; Date of completion: December 31, 2018; Total cost of the project: Rs. 9,00,000/-.

Division of Molecular Medicine

DR. ATIN KUMAR MANDAL

Associate Professor

Name of the Participants

Nilanjan Gayen, SRF; Baijayanti Ghosh, SRF; Pramit Bhattacharjee, SRF; Somesh Roy, JRF; Madhuparna Chakraborty, JRF; Dhiman Saha, JRF; Soumita Mukherjee, SERB-NPDF.

Collaborators

Dr. Anirban Bhunia, Bose Institute, Kolkata; Dr. Dhandapany Perundurai, InStem, Bangalore; Dr. Mohit Prasad, IISER, Kolkata.

Background

Understanding the protastasis network in balancing the proteome at physiological and stress condition

Organisms have evolved mechanisms known as protein quality control (PQC) to maintain homeostasis of proteome at physiological or stress condition. They utilize chaperones that bind to non-native polypeptides to prevent aggregation and to facilitate the folding of proteins, as well as degradation systems – the ubiquitin-proteasome system and autophagy – to degrade abnormal or damaged proteins. These components of PQC system act in concert to prevent the accumulation of misfolded proteins and/or to facilitate their elimination which is critical for cell survival. However, the efficiency of the PQC system is

often perturbed by environmental, cellular or genetic factors which generate stable toxic conformations having gain-of-function or aggregation prone cell toxic conformations. Generation of these toxic protein conformations are the causal reason for various diseases including cancer, diabetes, hypertrophy and late-onset neurological diseases. My lab is focused to understand the mechanism of cellular PQC and how the PQC is altered for mutant having gain-of-function or aggregation prone proteins.

Aims and Objectives

- To understand how cellular proteastasis is maintained at physiological and stress condition; and the involvement of chaperones and ubiquitin ligases in this process
- Gaining insights of RAF kinase regulation in order to identify the strategy to modulate its gain-of -function activity associated with pathological conditions such as cancer, cardiac hypertrophy
- Ubiquitin ligases in clearance of polyQ proteins, Atxn3/Huntingtin responsible for SCA3 and Huntington's diseases

Work Achieved

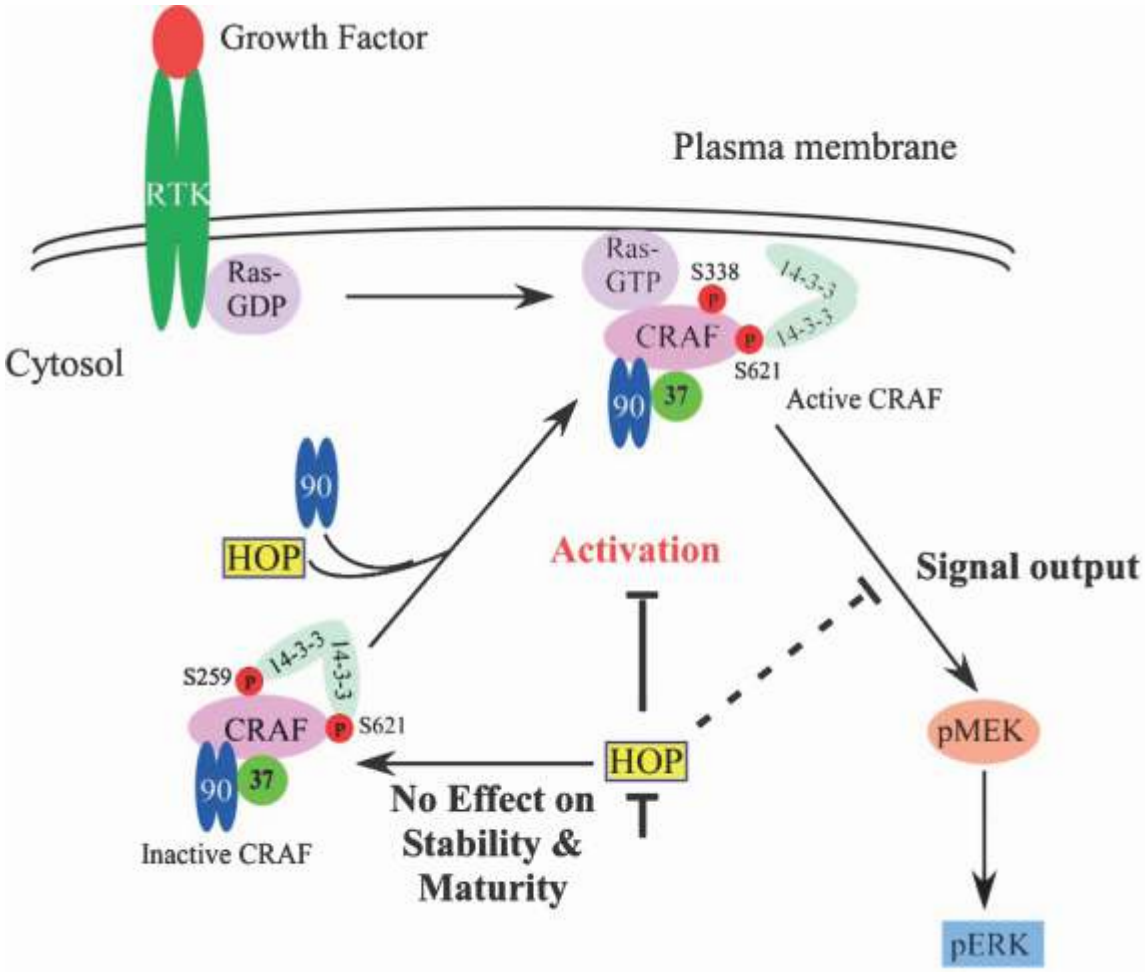
- We elucidated the role of Hsp90 co-chaperones, HOP (Hsp70/Hsp90 organizing protein) in maintaining CRAF activity. HOP is essential for CRAF kinase activity, but in contrast to Hsp90/Cdc37, it does not affect S621 phosphorylation of CRAF, necessary for CRAF stability and activity. The functionality of HOP in regulating CRAF activity is mediated by its TPR2A-2B-DP2 domain. This domain enhances the interaction with Hsp90 to CRAF and disruption of HOP-Hsp90 interaction is incapable in activating CRAF kinase. We also found that HOP enhances recruitment of Hsp90 to CRAF which in turn regulates actin-dependent translocation of the kinase during MAPK signaling. Thus, down-regulation of HOP not only reduces MAPK signaling mediated by CRAF kinase, but also the activity of mutant CRAF kinase associated with 'Rasopathy'.
- We identified the functional role of Praja1, an ubiquitin ligase highly expressed in brain tissue in clearing polyQ proteins, Ataxin-3 and Huntingtin associated with Spinocerebelar Ataxia-3 (SCA3) and Huntington's diseases.

Future Research Plans

- Collaboration of chaperones and ubiquitin ligases in triage of misfolded proteins
- Role of chaperones (Hsp70, Hsp40) and scaffold protein 14-3-3 in regulation of CRAF kinase
- Screening of ubiquitin ligases in degradation of mutant CRAF proteins
- Elucidating the functional role of Praja1 ubiquitin ligase in maintaining the proteome

Extramural Funding

- DST-SERB project entitled 'Role of co-chaperones in triage decision of Hsp70' 21st March, 2017- 20th March, 2020; Rs. 39,43,000/-
- DBT funded project entitled 'Raf1 quality control and development of pathological conditions' 01.11. 2014- 30.04.2018, Rs. 48,79,000/-



Schematic representation of HOP mediated regulation of CRAF kinas

Conference(s) / Workshop(s)

Abstracts (International – 2)

- The 9th International Conference of the Hsp90 Chaperone Machine'. Leysin, Switzerland, October 17-21, 2018, ,
- 'Protein Homeostasis in Health and Disease'. Cold Spring Harbor Laboratory, NY, USA, April 17- 21, 2018

Indian -2

- 10th East Zonal Oncology Symposium, Saroj Gupta Cancer Centre and Research Institute, Thakurpukur, Kolkata, January 19, 2019
- Society of Biological Chemists (I), Kolkata, Amity University, Kolkata, September 08, 2018

DR. GAURISANKAR SA

Professor

Name of the Participants

Suman Mukherjee, JRF; Saikat Dutta, JRF; Sayantan Bose, SRF; Dia Roy, SRF; Dwaipayan Chakraborty, SRF. Tania Sarkar, SRF; Subhadip Pati, SRF; Subhanki Dhar, SRF; Dr. Shravanti Mukherjee, RA; Dr. Debomita Sengupta, RA. Dr. Ranjita Das, RA; Dr. Aharna Guin, RA. Arindam Basu, Technical Officer-I; Bijoy Munsi, Helper.

Background

Anticancer immunotherapies involving the use of immune-checkpoint inhibitors (e.g., anti-CTLA4/-PD1) has emerged as new therapeutic pillars. While often many patients have innate-/acquired-resistance to immunotherapies. Avoidance of immune system is one of the major hallmarks in cancer progression that successively transforms immune-surveillance (tumor-eradication) to immune-tolerance (tumor-progression). Modulation of immune cells to harness the power of effective immune responses has been long-term goals for promising strategies of cancer immune therapy. However, long-term follow-up in a pooled meta-analysis exhibited long-term survival in approximately 20% of patients treated with immune checkpoint inhibitors, and a large fraction of patients experience aggressive disease progression after treatment. Earlier

we reported that FOXP3$^+$ Treg cells augmentation in cancer patients causes immunosuppression, neo-angiogenesis and metastasis. Recent research has thus focused on the development of effective immunotherapeutic strategies that target tolerogenic-immune cells to become immunogenic and restore cancer immune surveillance to bypass the innate or acquired resistance to immunotherapies.

Aims and Objectives

- To determine the status of the immune system in patients with different types of cancer.
- Unravelling the immune landscape of tumor microenvironment to understand the reason for development of innate or acquired resistance to immunotherapies.
- Improving the treatment outcome with additional modalities to overcome the failure of immunotherapy.
- To develop suitable combinations of chemotherapy, immunotherapy and rejuvenation-therapy to determine the efficacy of such therapy modules through clinical trials.

Work Achieved

- Identification of a novel CD4$^+$CD25$^+$CD127$^-$CTLA4$^+$FOXP3$^+$ T-regulatory (Treg) cells in tumor micro-environment.
- Presence of high-level of tumor-associated CD4$^+$ Treg cells (tTregs) in the tumor-site results in poor prognosis of cancer patient.
- This tTregs use altered energy metabolisms to survive and expand in highly competitive tumor microenvironment.
- This tTregs exploit several immunosuppressive strategies such as induction of T-effector cell death, dysfunction of dendritic cells, and modulation of anti-tumorigenic (M1) macrophages towards tolerogenic (M2) macrophages which prevents the natural immune system to act against tumor and thus develops the resistance to immunotherapies.
- This tTregs secrets high-level of VEGF to instigate endothelial cells to undergo tumor-angiogenesis.
- CD8+ Tregs in tumor microenvironment synergise CD4+ Tregs immunosuppressive power.
- Identification of a micro-RNA (miR-325) that controls the development and function of tumor-associated Treg cells.
- Lentivirus clone containing miR-325 can successfully generate an immunogenic response against tumor by restricting the immuno-suppression that is caused by tTregs in tumor-bearer.

Future Research Plans

- Determination of the status of the immune system in cancer patients for logistic application of immunotherapy.

- Development of adeno-associated virus-mediated in-vivo delivery system for miR-325 for clinical trials
- Development of engineered exosome-mediated in-vivo delivery system for targeted-delivery of hsa-miR-325-3p.
- To develop combinatorial therapy modules of chemotherapy, immunotherapy and miR-325 therapy for clinical trials.

Publications

1. Kajal K, Panda Ak, Bhat J, Chakraborty D, Bose S, Bhattacharjee P, Sarkar T, Chatterjee S, Kar SK, Sa G (2019) Andrographolide binds to ATP-binding pocket of VEGFR2 to impede VEGFA-mediated tumor-angiogenesis. Scientific Reports, 9: 4073.
2. Sarkar I, Pati S, Dutta A, Basak U, Sa G (2019) T-memory cells against cancer: Remembering the enemy. Cellular Immunology, 338: 27-31.
3. Sengupta P, Bhattacharya A, Sa G, Das T, Chatterjee S (2019) Truncated G-quadruplex isomers cross-talk with the transcription factors to maintain homeostatic equilibria in c-MYC transcription. Biochemistry. 58(15): 1975-1991.
4. Chakraborty S, Bhattacharjee P, Panda AK, Kajal K, Bose S, Sa G (2018) Clonal deletion of anti- tumorogenic $IFN^{hi}FOXP3^{-}$ $CD8^{+}$ Treg cells confine tumor immunosurvillance. Immunology & Cell Biology 96(10): 1035-1048.
5. Chakraborty S and Sa G (2018) CD8 + T-Regulatory cells: mechanisms of differentiation and function. J. Immunol. Science, 2: 2-9.
6. Chakraborty D, Pati S, Bose S, Dhar S, Saikat Dutta S and Sa G (2019) Cancer immunotherapy: present scenarios and the future of immunotherapy. The Nucleus, Doi:10.1007/s13237-019-00273-4.

Book Chapters / Invited Reviews

1. Panda AK, Chakraborty S, Kajal K, Roy D, Sarkar T and Sa G (2018) Role of proteases in tumor immune evasion. Springer Publishing Co, USA.

Invited Talks

1. Delivered Invited Lecture at the 7th Federation of Immunological Societies of Asia-Oceania Congress (FIMSA-2018) at Bangkok, Thailand.
2. Invited as a Key Speaker at the BIT's 16^{th} Annual Conference on International Drug Discovery Science and Technology, held in Boston, USA.
3. Delivered talk as an Invited Faculty at the International Conference of Asian Society of Mastology held in Maldives.
4. Delivered Key-note address at the Immunocon-2018 at TISTI, Faridabad, India
5. Delivered Invited Lecture at the Indo-Australian Biotechnology Conference at Mumbai, India.

6. Delivered Invited Lecture at the Indo-USA conference at IISc, Bengaluru, India
7. Delivered Invited Lecture at the Indo-Japan conference at Kolkata, India
8. Invited to deliver Inaugural Speech at the International Seminar on Homeopathy and Auxiliary Therapy of Oncology held in Nasik, India.
9. Delivered Plenary Lecture at the International Conference of Pysiologfical Society of India Physicon-2018 at Sreerampore College, India.
10. Delivered plenary lecture as a Resource Person at the Immunology Day at PGMIR, Chandigarh, India
11. Delivered Key-note address at the Flowcytometry Meeting-2019 at JNCSER, Bengaluru, India
12. Delivered Key-note address at the World Cancer Day at CNCI, Kolkata, India
13. Delivered plenary lecture at NEHU, Shilong, India
14. Delivered plenary lecture at VU, Midnapore, India
15. Delivered Invited Lecture at the RMRC-2018 at Guwahati, India

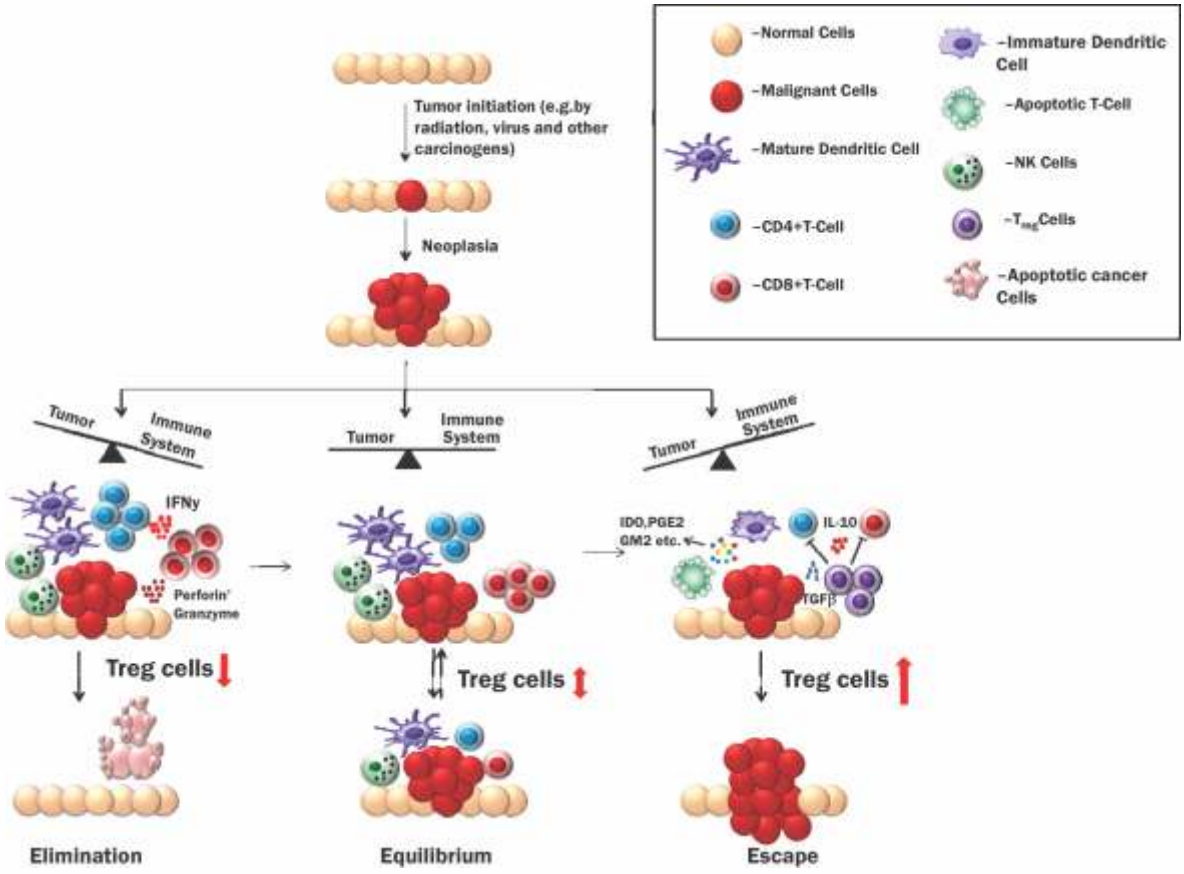


Figure: Tumor-associated T-regulatory cells exploit several immunosuppressive strategies which prevents natural immune system to act against tumor and thus escape anti-tumor immunity.

16. Delivered plenary lecture at Kalyani University, Kalyani, India
17. Delivered plenary lecture at Lady Brabourne College, Kolkata, India
18. Delivered plenary lecture as a Resource Person at the Refresher's Course of Dept. of Physiology, Calcutta University, Kolkata, India
19. Invited for delivering lecture at the 38th Annual Convention of Indian Association for Cancer Research at Chandigarh, India.

Extramural Funding

1. DBT-funded: Investigation of the transcriptional regulation of miR-325 and evaluating its potential as a therapeutic agent for cancer. Rs. 88.34 Lakhs
2. DBT-funded: Development of delivery system for miR-325-3p for immunotherapy of cancer. Rs. 95.20 Lakhs
3. DST-funded: Role of cancer stem cells in tumor neo-angiogenesis: A mechanistic study. Rs. 70.00 Lakhs
4. DST-funded: Understanding the role of G-quadruplex structures in BCl-2, KRAS and c-MYC promoters in the development of cancer. Rs. 50.00 Lakhs
5. DST-funded: miR-325: A distinct microRNA that controls T-regulatory cells. Rs. 51.68 Lakhs

Awards / Honours / Memberships

Editor-in–Chief: International J Immunology

Sectional Editor: Scientific Reports, Proceeding of National Academy of Science, India, Section-B, Head & Face Medicine; Austin J. Clinical Immunology, J Cancer Research & Molecular Medicine

Conference(s) / Workshop(s) : 19

DR. KAUSHIK BISWAS
Associate Professor

Name of the Participants

Dr. (Mrs.) Dipanwita Chakraborty, DBT RA; Mr. Shibjyoti Debnath, SRF (UGC Adhoc); Mr. Abhisek Sarkar, SRF (UGC Adhoc); Miss Elora Khamrui, JRF (CSIR Adhoc); Mr. Sounak Banerjee, JRF (UGC Adhoc); Mr. Subha Ray, JRF (UGC Adhoc).

Background

Over-expression of glycosphingolipids are found to be associated with a large number of cancers. However, the precise role of these glycolipids in the process of tumorigenesis is not known. Detailed mechanistic studies aimed towards understanding their precise mode of action in modulating tumor growth, progression or metastasis are also lacking. Our laboratory is engaged in defining the functional role of some of these glycosphingolipids, particularly gangliosides in tumorigenesis, and identifying the mechanism by which they do so.

Aims and objectives

a) The consequence of such an over-expression in tumors.

b) The basis of over-expression of select glycosphingolipids in cancer.

Work Achieved

a) Identification of a novel role of ganglioside GM2 in tumor cell migration and invasion through involvement of the integrin signaling pathway.

b) Design, construction and generation of stable GM2-synthase knockout mouse cell lines using targeted genome editing techniques like TALEN and CRISPR.

c) Defining the critical role of ganglioside GM2 in mediating lung metastasis in an experimental animal tumor model.

d) Identification a novel epigenetic mechanism in the transcriptional regulation of the GM2-synthase gene in cancer.

Future Research Plans

a) Delineating the mechanism of GM2-mediated epithelial-mesenchymal transition (EMT) – understand the role of HIPPO-YAP/TAZ signaling axis in GM2-mediated EMT and metastasis.

b) Identification of the molecular machinery (proteome) involved in the epigenetic regulation of the GM2-synthase gene - extend the applicability of the genome editing tool, CRISPR, by using CRISPR-dCas9 for an "en-ChIP" assay which will help pull down the entire proteome associated with the TSS of the GM2-synthase gene.

Students awarded Ph.D. - 3

a) Manjari Kundu, PhD awarded from Calcutta University on 2017

b) Barun Mahata (CU, 2018) Study the role and elucidate the mechanism of tumor derived Gangliosides in tumor growth, progression and metastasis in syngenic mouse tumor model.

c) Pravat Parida (CU, 2019) Synthesis, characterization and mechanistic studies of the stilbene derivatives as anticancer agents.

d) Avisek Banerjee, PhD thesis submitted on December 2018

Publications

1. Banerjee A, Mahata B, Dhir A, Mandal T K, Biswas K (2019) Elevated histone H3 acetylation and loss of the Sp1-HDAC1 complex de-repress the GM2-synthase gene in renal cell carcinoma. *J. Biol Chem.*, 294 (3), 1005-1018.

2. Dhabal S, Das P, Biswas P, Kumari P, Yakubenko VP, Kundu S, Cathcart MK, Kundu M, Biswas K, Bhattacharjee A. (2018) Regulation of monoamine oxidase A (MAO-A) expression, activity, and function in IL-13-stimulated monocytes and A549 lung carcinoma cells. *J. Biol Chem., 293(36), 14040-14064.*

3. Parida P K, Mahata B, Santra A, Chakraborty S, Ghosh Z, Raha S, Misra A K, Biswas K, Jana K (2018) Inhibition of cancer progression by a novel trans-stilbene derivative through disruption of microtubule dynamics, driving G2/M arrest, and p53-dependent apoptosis., *Cell Death Dis., 9(5):448.*

Book Chapters / Invited Reviews

"Generation of stable knockout mammalian cells by TALEN-mediated locus specific gene editing." Barun Mahata and Kaushik Biswas, *Methods Mol Biol., 1498, 107-120, 2016.*

Invited Talks

Presented an invited talk titled "Understanding the role of glycosphingolipid GM2 in tumorigenesis" at Recent trends and advancements in regenerative medicine & the role of biomarkers in health, organized by the Department of Zoology, University of Kerala on March 2019.

Extramural Funding

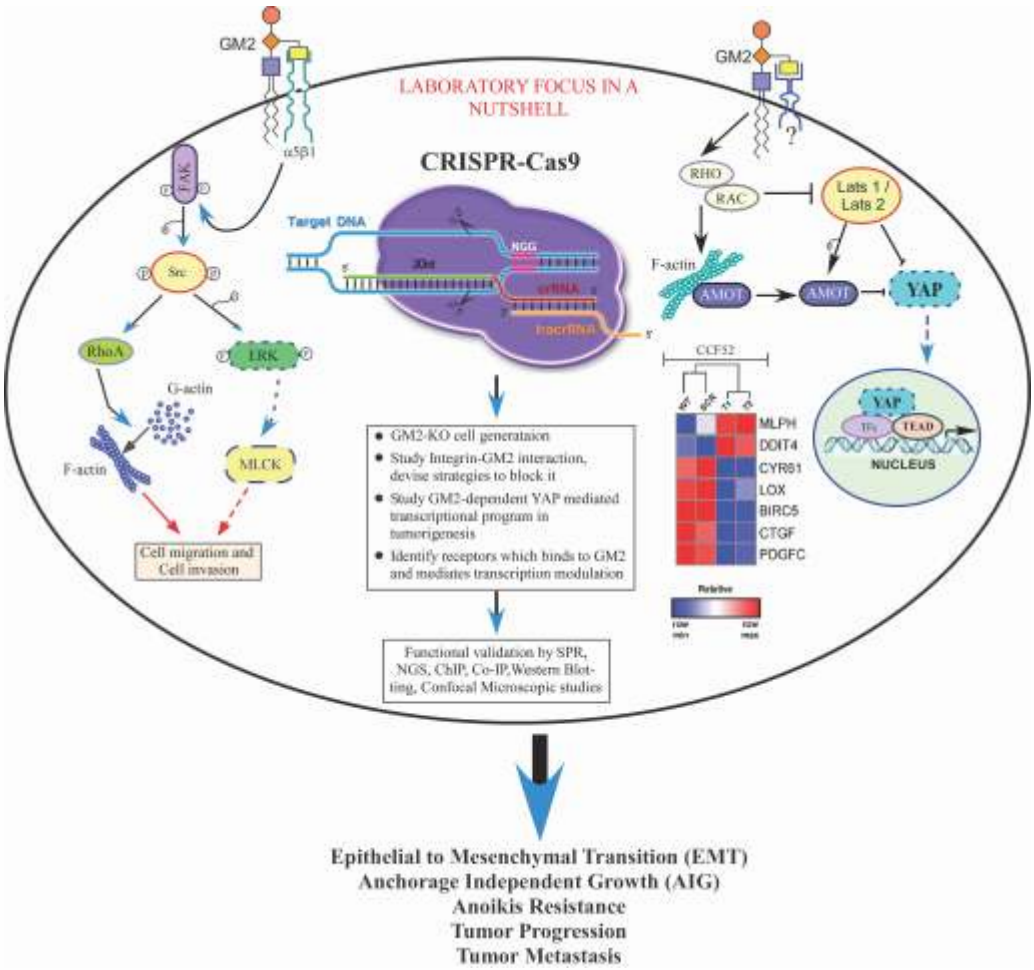
a) "A Novel role of ganglioside GM2 in the regulation of the Hippo signaling pathway in tumorigenesis.", DST-SERB, Sanction No. EMR/2016/001983, dated Mar 14, 2017.

b) "Role of c-Jun N-terminal kinase (JNK) in tumor derived soluble factor mediated T cell apoptosis." DBT, Sanction No. 6242-P51/RGCB/PMD/DBT/KBWS/2015, Termination date – May 27, 2019.

c) "Understanding the role of tumor derived glyco-sphingolipids in carcinogenesis : An *in vivo* approach." DBT, Sanction No. BT/PR5338/MED/30/989/2013, Termination date – May 12, 2018.

Conference(s) / Workshop(s)

Abstracts – FOUR (International – ONE; National – THREE)



DR. NRIPENDRANATH MANDAL

Professor

Name of the Participants

Sourav Panja, Institute Fellow (SRF); Debabrata Mondal, DST Inspire fellow (SRF); Tapasree Basu Mallik, Ad hoc UGC Fellow (SRF); Anil Khushalrao Shendge, Ad hoc CSIR Fellow (SRF); Ranjit Kumar Das, Helper-D.

Background

Prof. Mandal's laboratory has conducted research in the field of **Marine Biotechnology** and **Medical Biotechnology** for disease management in aquatic organism and human system.

Aims and Objectives

- Development of more specific and sensitive molecular based tools for early prediction or diagnosis of disease risk in human as well as aquatic animal
- Development of better and safer Eco-friendly medicine against various diseases from natural resources as well as synthetic small molecules

Work Achieved

Marine Biotechnology Research :

The giant black tiger shrimp, *Penaeus monodon* (Fabricius) is one of the valuable captured and cultured

marine shrimp species has been relentlessly affected due to several viral pathogen related diseases across the world. Among these viral pathogens, white spot syndrome virus (WSSV) is the causative agent of white spot disease (WSD). 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 brood-stocks for disease free shrimp aquaculture industry as well as to identify novel gene linked to disease resistance phenomenon.

We have developed so far thirteen (13) DNA markers (442 bp, 236 bp, 71 bp, 457 bp, 848 bp, 773 bp, 299 bp, 262 bp, 172 bp, 213 bp, 244 bp, 279 bp, and 402 bp) to identify disease resistant population of *P. monodon*. Among recently developed five (172 bp, 213 bp, 244 bp, 279 bp, and 402 bp) DNA marker, 244 bp and 279 bp microsatellite DNA markers has the significant sequence homology with non-Reverse Transcriptase domain of Penelope-like retroelement (MjPLE01) clones. For the first time, we have experimentally revealed that novel Penelope-like retroelement fragments is present in *P. monodon* genome, and flanking region of 244 bp and 279 bp microsatellite DNA markers showed that these two markers were originated from novel Penelope-like retroelement as well as antiviral (AV) gene of *P. monodon*. First time, we have also isolated and submitted novel telomeric and sub-telomeric sequences of *P. monodon* in the GenBank, NCBI. We have also identified and characterized disease resistance and disease susceptibility linked novel microRNAs in marine shrimp (*P. monodon*).

Medical Biotechnology Research

The Medical Biotechnology program is primarily focussed towards developing orally administrable ecofriendly natural/synthetic medicine from various medicinal plants/algae/lichens against non-communicable diseases (iron-overload induced hepatotoxicity, inflammation and cancer).

We have developed some orally administrable medicine from natural resources for amelioration against iron-overload induced toxicity by chelating iron or by trapping free radicals (as antioxidant). In addition to endogenous antioxidant systems, consumption of natural supplements rich in antioxidants alters the redox environment thereby lowering risk of various oxidative stress-related diseases. This year, we have focused on isolation of various phytocompounds specially, flavones, phenols and napthoquinones and their structural elucidation. From the insectivorous plant, *Drosera burmannii*, compounds like **Plumbagin**, **Quercetin**, **Morin** and **Tannic acid** have been isolated. Similarly, isolation from plant *Clerodendrum viscosum* led to phytocompounds such as **Apigenin**, **Acacetin**, **2,3-Dihydroxy benzoic acid** and **Ellagic acid**. **Methyl palmitate**, **Lauric acid**, **Myristic acid**, **Docosahexanoic acid**, **Eugenol** and **Hexagol** were isolated from micro algae, *Euglena tuba*. Recently we have investigated the activity of **tannic acid** and **ellagic acid** for ameliorating iron-overloaded toxicity of liver in mice. We have also published a model (Figure 1) proposing mechanism of ellagic acid against iron-overload induced hepatotoxicity through inhibition of oxidative stress and apoptotic pathway in **Biomedicine and Pharmacotherapy**.

Since cancer is one of the dreaded diseases in the present global scenario with millions of incidences of affected patients and associated deaths, we have also screened all these isolated compounds for anticancer activities. Most of them showed promising anticancer activities and

further investigations are carried on for in-depth mechanistic study. Another **novel quinoline compound, 7-hydroxy-6-methoxyquinolin-2(1H)-one** has been isolated for the first time from *Spondias pinnata* bark and it has been reported to have excellent anti-inflammatory properties via NFkB pathway activation.

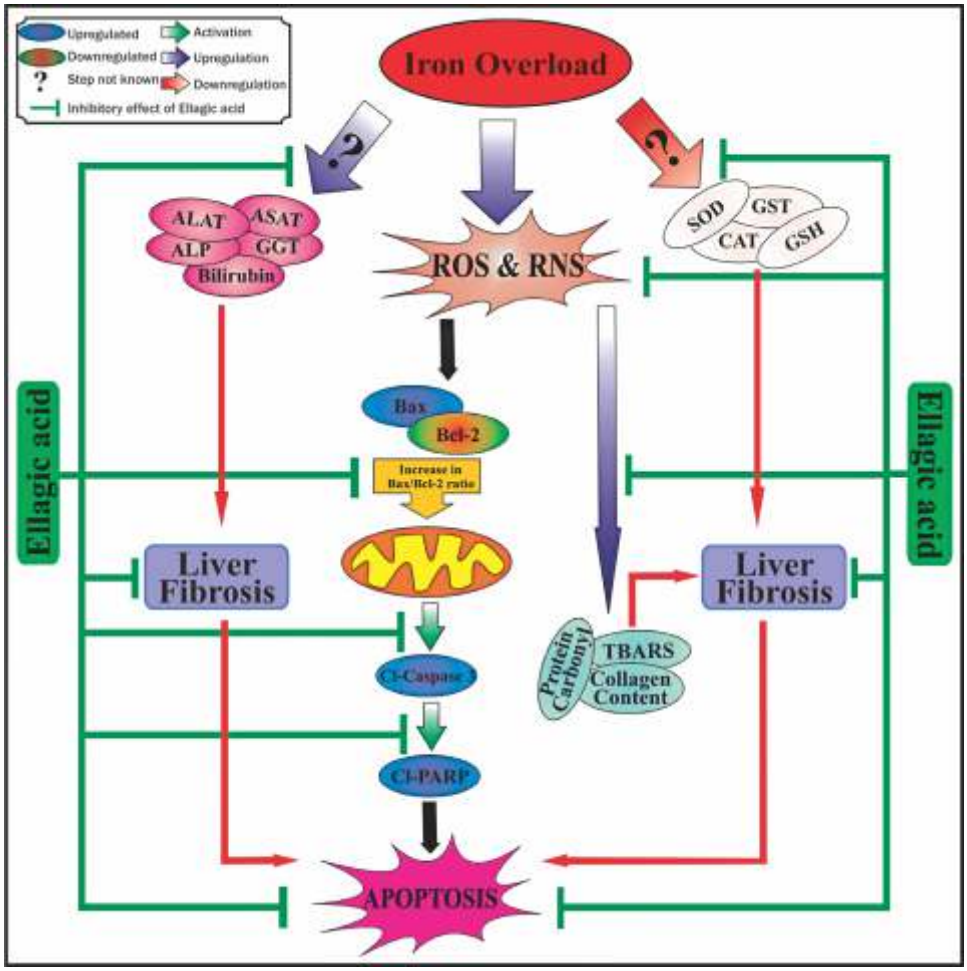


Figure 1: Proposed mechanism of hepatoprotective activity of ellagic acid against iron-overload induced hepatotoxicity

Apart from natural products array of green fluorescence organometallic synthetic supramolecular metal-based complexes [Ru(II), Pd(II) and Ir(III) metalla-rectangles] containing BODIPY-based linker have been investigated this year. The Ir(III) metallocomplexes have been used as a tracking tool under a confocal microscope to investigate the intracellular regions where the compounds were localized in various cancer cells. Many such compounds showed better toxicities against breast, cervical and glioblastoma cells than normal lung fibroblast cells and some showed activities even better than cisplatin against breast carcinoma (MCF-7) and glioblastoma (U87) cell lines. Presently, we are actively working on many such series of compounds and isolated phytochemicals for our search of better and safer eco-friendly medicine to combat cancer.

Division of Molecular Medicine

Future Research Plans

The future plan for **Marine Biotechnology** program is the characterization of developed microsatellite DNA markers to identify the disease-resistant brood-stocks for disease free shrimp aquaculture industry as well as to identify novel gene linked to disease resistance in marine shrimp. The future plan for **Medical Biotechnology** program is to study in-depth mechanisms of various phytocompounds from medicinal plants/algae/lichens for anticancer and anti-inflammatory activities in animal model for developing eco-friendly medicine.

Students Awarded Ph.D.

Sourav Panja (CU, 2018) Study of Antioxidant and Anticancer Activities of A Microalgae, Euglena tuba (Carter), from Rarh Region of West Bengal

Publications

1. Ghate N B, Chaudhuri D, Panja S, Singh S, Gupta G, Lee C Y and Mandal N (2018) *In Vitro* Mechanistic Study of the Anti-inflammatory Activity of a Quinoline Isolated from *Spondias pinnata* bark. *Journal of Natural Products* 81:1956–1961. DOI: 10.1021/acs.jnatprod.8b00036 (Impact factor: 3.88).
2. Shendge A K, Basu T, Panja S, Chaudhuri D and Mandal N (2018) An ellagic acid isolated from *Clerodendrum viscosum* leaves ameliorates iron-overload induced hepatotoxicity in Swiss albino mice through inhibition of oxidative stress and the apoptotic pathway. *Biomedicine & Pharmacotherapy* 106: 454–465 (Impact factor: 3.457).
3. Gupta G, Das A, Lee S W, Ryu J Y, Lee J, Nagesh N, Mandal N and Lee C Y (2018) BODIPY-based Ir (III) rectangles containing bis-benzimidazole ligands with highly selective toxicity obtained through self-assembly. *Journal of Organometallic Chemistry* 868: 86 – 94. DOI: 10.1016/j.jorganchem.2018.04.034 (Impact factor: 2.173).
4. Basu T, Kumar B, Shendge A K, Panja S, Chugh H, Gautam H K and Mandal N (2018) An Indian Desert Shrub 'Hiran Chabba', *Farsetia Hamiltonii* Royle, Exhibits Potent Antioxidant and Hepatoprotective Effect Against Iron-Overload Induced Liver Toxicity in Swiss Albino Mice. *Current Drug Discoveries and Technologies* 15: 1-13. DOI: 10.2174/1570163815666180418150123 (Impact factor: 4.77).

Extramural Funding

1. "Molecular characterization of developed DNA markers linked to disease resistance/ susceptibility in giant black tiger shrimp, *Penaeus monodon*" funded by DST-SERB (2015-2018), Total amount Rs. 48.668 lakhs.

Awards / Honours / Memberships

1. Member (Visitor's Nominee) of faculty selection committee, Department of Chemistry, IIT Kanpur, August 14, 2018.
2. Member (Visitor's Nominee) of Academic Council, Sikkim University (Central University) 03-08-2018 to 02-08-2020.
3. Member, Board of Studies, Life Science, Central University of Himachal Pradesh 04-09-2017 to 03-09-2020.

DR. MAHADEB PAL

Professor

Name of the Participants

Suvranil Ghosh, SRF; Naibedya Dutta, SRF; Anirban Manna, SRF; Samhita De, SRF; Chirantan Majumder, SRF; Hossainoor R Sareng, JRF; Dr. Ayan Mandal, RA; Papri Basak, RA.

Background

A normal cell removes toxicity associated with protein mis-folding through activating proteotoxic stress response (PSR). PSR works through up-regulation of inducible protein chaperones (HSPs) along with proteasome and autophagy pathway. Heat shock factor 1 (HSF1) controls PSR upon sensing mis-folded protein. Under neurodegenerative and cancer conditions cells lose standard control over their HSF1 function. A cell with Parkinson's disease, dies due to its inability to sense a misfolded protein, and upregulate HSF1 function. Forced upregulation PSR ameliorates the protein mis-folding associated toxicity in cell and animal model. Thus far however no specific small molecule activator of HSF1 has reached the clinic. Cancer cells require constitutively activated state of HSF1. Understanding these processes at the molecular level should help develop strategy to intervene cancer with better efficacy. A small molecule inhibitor of HSF1 would also carry a great anticancer therapeutic potential.

Division of Molecular Medicine

Aims and Objectives

- Understand the molecular basis of control of HSF1-mediated gene regulation under proteotoxic stress
- Isolate small molecule modulators (inhibitor and activator) of HSF1 functions from natural sources
- Study mechanism of actions of small molecules isolated to obtain insights into HSF1-mediated gene regulation as well as to evaluate their therapeutic potentials

Work Achieved

Identified for the first time

- a fundamental mechanism of association of HSF1 with cellular inflammation and cancer by demonstrating that HSF1 driven assembly of an multiprotein enhanceosome at the 3'UTR induces TNF gene as a pioneering signal for inflammation under proteotoxic stress (Ali et al FASEB J 2019).
- a cross-talk between the HSF1 (basic machinery of PSR/cytoprotective mechanism) and antioxidant stress response by demonstrating that NRF2, a central regulator of antioxidant response, controls HSF1 gene expression under oxidative stress (Paul S et al JBC 2018).
- that Azadiradione significantly delay the onset of Huntington's disease in mice (Singh B et al Molecular Neurobiology 2018). Earlier azadiradione was isolated in the lab from neem as a direct activator of HSF1 (Nelson et al Oncotarget 2016).
- a couple of activities to nearly single molecule level from *Ervatamia coronaria* and *Bergenia ligulata* that act against colon tumor and prostate cancer, respectively carrying HSF1 inhibitory activity (ms in prep)

Future Research Plans

Understand role of azadiradione (AZD) in Parkinson's model of mice and associated cellular biology in cellular transcriptome and proteomes; Understand the pharmacophore in AZD and molecular basis of HSF1-AZD interaction through undertaking biophysical approaches.

Students Awarded Ph.D.

Joyita Hazra (CU, 2018) : Study the role of DNA-PK and Paf1c in heat shock induced gene expression in human cells.

Asif Ali (CU, 2019) : Studies on the role of proteotoxic stress in cellular inflammation.

Publications

1. Ali A, Biswas A and Pal M (2018) HSF1 mediated TNF- production during proteotoxic stress response pioneers proinflammatory signal in human cells. FASEB J. 2019 Feb;33(2):2621-2635. doi: 10.1096/fj.201801482R. Epub 2018 Oct 11

2. Paul S, Ghosh S, Mandal, S, Sau S and Pal M (2018) NRF2 transcriptionally activates the heat shock factor 1 promoter under oxidative stress and affects survival and migration potential of MCF7 cells. J Biol Chem. 2018 Dec 14;293(50):19303-19316.

3. Singh B, Vatsa N, Nelson V, Kumar V, Kumar S, Mandal S, Pal M and Jana N (2018) Azadiradione Restores Protein Quality Control and Ameliorates the Disease Pathogenesis in a Mouse Model of Huntington's Disease, *Mol Neurobiol*. doi: 10.1007/s12035-017-0853-3.

4. Mukherjee A, Ghosh S, Sarkar R, Samanta S, Ghosh S, Pal M, Majee A, Sen S K, Singh B (2018) Synthesis, characterization and unravelling the molecular interaction of new bioactive 4-hydroxycoumarin derivative with biopolymer: Insights from spectroscopic and theoretical aspect. J Photochem Photobiol B. 189:124-137. doi: 10.1016/j.jphotobiol.2018.10.003. Epub 2018 Oct 13.

Invited Talks

Delivered in

3rd International Conference on Nutraceuticals and Chronic Diseases (INCD) held in Dehradun (September 14-16, 2018).

38th International convention organized by Indian association for cancer research (IACR) held in PGIMER, Chandigarh (March 1-3 2019) .

Extramural Funding

i) Project entitled "Understand regulation of heat shock factor 1 activities in human cells" funded by SERB, DST for three years starting Dec 2018 (~ 31 lac for 3 yr).

ii) DBT project entitled: Understand molecular mechanism of action of a protein chaperone inducer azadiradione and its therapeutic development for Parkinson's disease treatment" started since January 2018 for three year (~ 36 lac for 3 years).

Conference(s) / Workshop(s)

Attended FASEB meeting entitled "Protein Folding in the Cell" during July 22-27, 2018 held in Olean, New York.

Division of Molecular Medicine

DR. PARAMES CH. SIL
Professor

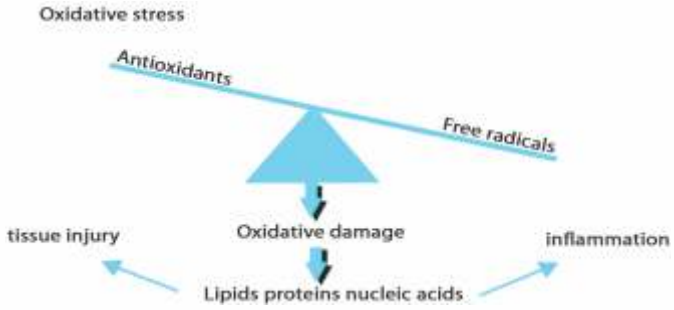
Name of the Participants

Sharmistha Banerjee, SRF; Sayanta Dutta, SRF; Sumit Ghosh, SRF; Sushweta Mahalanobish, SRF; Mousumi Kundu, SRF; Sayanta Sarkar, JRF; Noyel Ghosh, JRF; Sharmistha Chatterjee, JRF; Abhishek Kumar Das, JRF; Uday Hossain, JRF; Ankita Mandal, JRF.

Background

Our laboratory investigates several major areas of oxidative stress-mediated organ pathophysiology and diseases, like diabetes, heavy metal toxicity, cancer, etc. These are currently the major contributors to world fatality and in most of the cases, optimal therapeutic options with minimal side-effects are yet to be maneuvered. We focus on discovering leads, preferably natural or endogenous bioactive compounds, for the amelioration of these conditions. We also investigate on nanoparticle-mediated targeted drug delivery, to increase bioavailability of major drugs, besides minimizing their systemic toxicity. Our lab also focuses on unraveling the signal transduction mechanisms involved in multiple vital organs which falter under several pathophysiological conditions including diabetes, neurodegenerative diseases, cancer, colitis, as well as drug and heavy-metal induced tissue damage. Apart from these, we also work on identification and evaluation of novel, synthetic,

selectively ROS inducing anti-neoplastic compounds. Our research underlines the importance of maintenance of redox homeostasis inside our body.



Aims & Objectives

The main focus of our lab is to develop novel therapeutics against cancer and diabetes. In order to fulfil these broad ideas, we outline the major objectives of our research:

- Exploration of the ameliorative effects of bioactive molecules against neurodegenerative disorders
- Investigation of signaling mechanisms associated with the protective effects of natural antioxidants against diabetic complications
- Studies on nanoparticle-mediated stimuli-responsive targeted drug delivery in cancer
- Identification and evaluation of novel, synthetic, selectively ROS inducing anti-neoplastic compounds

Work Achieved

- We have synthesized uniquely engineered quercetin loaded phenyl boronic acid tagged zinc oxide nanoparticles allowed targeted delivery and more drug bioavailability to the breast cancer cells.
- We have discovered that genistein can significantly ameliorate arsenic-induced cytotoxicity. The underlying signalling mechanism behind the cytotoxicity of arsenic was investigated and revealed that genistein exhibited neuroprotection significantly by modulating the JNK3 mediated apoptosis, ERK1/2 mediated autophagy and TNF associated inflammatory pathways.
- Our study has revealed a mechanistic basis of mangiferin action against cisplatin induced nephrotoxicity. We also found thatMangiferin shows synergistic anticancer activity with cisplatin, and hence, it could be considered as a promising drug candidate, to be used in combination with cisplatin.
- We have also found that Mangiferin alleviates arsenic induced oxidative lung injury via upregulation of the Nrf2-HO1 axis.
- We have discovered that Sulphur dioxide ameliorates colitis related pathophysiology and inflammation.

Future Research Plan

- Investigating effects of bioactive compounds with antioxidant and anti-inflammatory property can manage ROS and FFAs level modulated diabetic complications and management of insulin resistance mediated non-alcoholic fatty liver disease (NAFLD).

- Achieving targeted, stimuli-responsive drug delivery to cancer cells by synthesizing novel nanohybrid carriers.
- Investigation would be focused on the study of signaling mechanisms involved in the protective effects of cuminaldehyde against rotenone induced Parkinson's disease.
- The protective effects of -ketoglutarate and taurine (both potent endogenous bioactive molecules) are being studied on an animal model of colitis.

Students Awarded Ph.D.

- Shatadal Ghosh
- Sayantani Chowdhury
- Pritam Sadhukhan
- Sukanya Saha

Publications

1. Banerjee S, Ghosh S, Sinha K, Chowdhury S, Sil P C (2019) Sulphur dioxide ameliorates colitis related pathophysiology and inflammation. *Toxicology* 412:63-78.
2. Mahalanobish S, Saha S, Dutta S, Sil P C (2019) Mangiferin alleviates arsenic induced oxidative lung injury via upregulation of the Nrf2-HO1 axis. *Food Chem Toxicol* 126:41-55.
3. Chowdhury S, Ghosh S, Das AK, Sil P C (2019) Ferulic acid protects hyperglycemia-induced kidney damage by regulating oxidative insult, inflammation and autophagy. *Front Pharmacol* 10:27.
4. Sadhukhan P, Kundu M, Rana S, Kumar R, Das J, Sil P C (2019) Microwave induced synthesis of ZnOnanorods and their efficacy as a drug carrier with profound anticancer and antibacterial properties. *Toxicol Rep* 6:176-185.
5. Sadhukhan P, Kundu M, Chatterjee S, Ghosh N, Manna P, Das J, Sil P C (2019) Targeted delivery of quercetin via pH-responsive zinc oxide nanoparticles for breast cancer therapy. *Mater Sci Eng C Mater Biol Appl* 100:129-140.
6. Kundu M, Sadhukhan P, Ghosh N, Chatterjee S, Manna P, Das J, Sil P C (2019) pH-responsive and targeted delivery of curcumin via phenylboronic acid-functionalized ZnO nanoparticles for breast cancer therapy. *J Adv Res*18, 161-172.
7. Ghosh S, Chowdhury S, Das AK, Sil P C (2019) Taurine ameliorates oxidative stress induced inflammation and ER stress mediated testicular damage in STZ-induced diabetic Wistar rats. *Food Chem Toxicol* 124:64-80.
8. Saha S, Sadhukhan P, Mahalanobish S, Dutta S, Sil P C (2018) Ameliorative role of genistein against age-dependent chronic arsenic toxicity in murine brains via the regulation of oxidative stress and inflammatory signaling cascades. *J Nutr Biochem* 55:26-40.
9. Ghosh S, Chowdhury S, Sarkar P, Sil P C (2018) Ameliorative role of ferulic acid against diabetes associated oxidative stress induced spleen damage. *Food Chem Toxicol* 118:272-286.

10. Dutta S, Saha S, Mahalanobish S, Sadhukhan P, Sil P C (2018) Melatonin attenuates arsenic induced nephropathy via the regulation of oxidative stress and inflammatory signaling cascades in mice. *Food Chem Toxicol* 118:303-316.

11. Sadhukhan P, Saha S, Dutta S, Sil P C (2018). Mangiferin ameliorates cisplatin induced acute kidney injury by upregulating Nrf-2 via the activation of PI3K and exhibits synergistic anticancer activity with cisplatin. *Front Pharmacol* 9:638.

Book Chapters / Invited Reviews

- Chatterjee S, Sil P C (2019) Targeting the crosstalks of Wnt pathway with Hedgehog and Notch for cancer therapy. *Pharmacol Res* 142: 251-261.
- Ghosh N, Hossain U, Mandal A, Sil P C (2019) The Wnt signaling pathway: a potential therapeutic target against cancer. *Ann N Y Acad Sci* 1443(1), 54-74.

Extramural Funding

- Targeting the miRNA axis with a synthetic small molecule, Nifetepimine to restrict migration of triple negative breast cancer cells; SERB (EMR/2016/000589) Total project value: Rs. 43.13 lakhs.
- Targeting onco-miRNAs with a novel oleic acid-pluoronic stabilized porousTiO 2 nanoparticle for specific synergistic delivery of small molecule combination to combat triple negative breast cancer; DST (SR/NM/NS-1099/2016) Total project value: Rs. 42.91 lakhs
- Nanoparticle-mediated co-delivery of chemotherapeutic drugs and genes for synergistic cancer treatment; DST (EMR/2016/002185) Total project value: Rs. 28.67 lakhs.

Awards/Honours/Memberships

The New York Academy of Sciences

The Indian Science Congress Association

Indian Society of Cell Biology

Indian Society of Biological Sciences

DNA Society of India

Editorial Advisory Board member: Biochemical Pharmacology

Associate Editor: Toxicology Reports

Regional Editor: Current Diabetes Reviews

Editorial Board Member: Frontiers in Oncology; Heliyon; ROS

Conference(s)

- International Symposium on frontiers in development & molecular medicine: Models to insights at Biswa Bangla Convection Centre, Kolkata, West Bengal, India, March 1-3, 2019.
- UGC-SAP (DRS-II)-Sponsored National Symposium on Modern Perspectives of Research & Development in Biochemistry & Biophysics at Department of Biochemistry and Biophysics, University of Kalyani, March 14 – 15, 2019: Poster presentation.

DR. TANYA DAS
Professor

Name of the Participants

Udit Basak, Apoorva Bhattacharya, Poulami Khan, Sourio Chakraborty, Shruti Banerjee, Deblina Guha, Aparajita Das, Abhishek Dutta, Arijit Bhowmik, Swastika Paul, Apratim Dutta.

Background

Cancer figures amongst the most devastating causes of global morbidity and mortality. Despite thorough research and implementation of novel therapeutic approaches, cancer still remains undefeated with tumor recurrence being the major hurdle. Recent researches have indicated the existence of a distinct subset of stem-like highly resistant cells within the tumor mass, adorned with the potential of self-renewal and multi-lineage differentiation. These cells, designated as cancer stem cells (CSCs) have been hypothesized to uniquely initiate, metastasize and sustain disease. Moreover, CSC subpopulation of the tumor is thought to be responsible for both therapy resistance and tumor recurrences. CSC-targeted approach is, therefore, needed to conquest the vicious battle against cancer. However, targeting of these resistant cells is extremely difficult since most of the basic properties of CSCs are still the Cinderella of Investigation. Therefore, the vision of my lab is to investigate in detail the basic properties of CSCs and

their contribution in cancer development, sustenance and relapse, to develop strategies for effectively targeting CSCs for eradicating cancer from its origin.

Aims and objectives

- To understand the basic properties of CSCs and their contribution in the 'Hallmarks of Cancer', i.e., tumor initiation, angiogenesis, metastasis, drug-resistanceetc.
- To explore the role of CSCs in tumor relapse and the underlying mechanisms
- To delineate the mechanisms of CSC-induced immune-evasion that might play a major role in tumor-survival during initiation, secondary tumor formation and relapse
- To investigate CSC-mediated reprogramming of the molecular choreography of cellular energy metabolism
- To repurpose FDA-approved drugs or utilize Indian phytochemicals or employ anti-stemness microRNAs to target CSCs

Work Achieved

Prof. Tanya Das has made significant contribution in attestingthat cancer stem cells(CSCs) are the 'Master Regulators' of all the 'Hallmarks of Cancer' (Figure 1).

- Her work identified CSCs as the root-cause of tumor relapse, a major reason behind patient's death. In fact, during chemotherapy, CSCs not only divide symmetrically to avoid

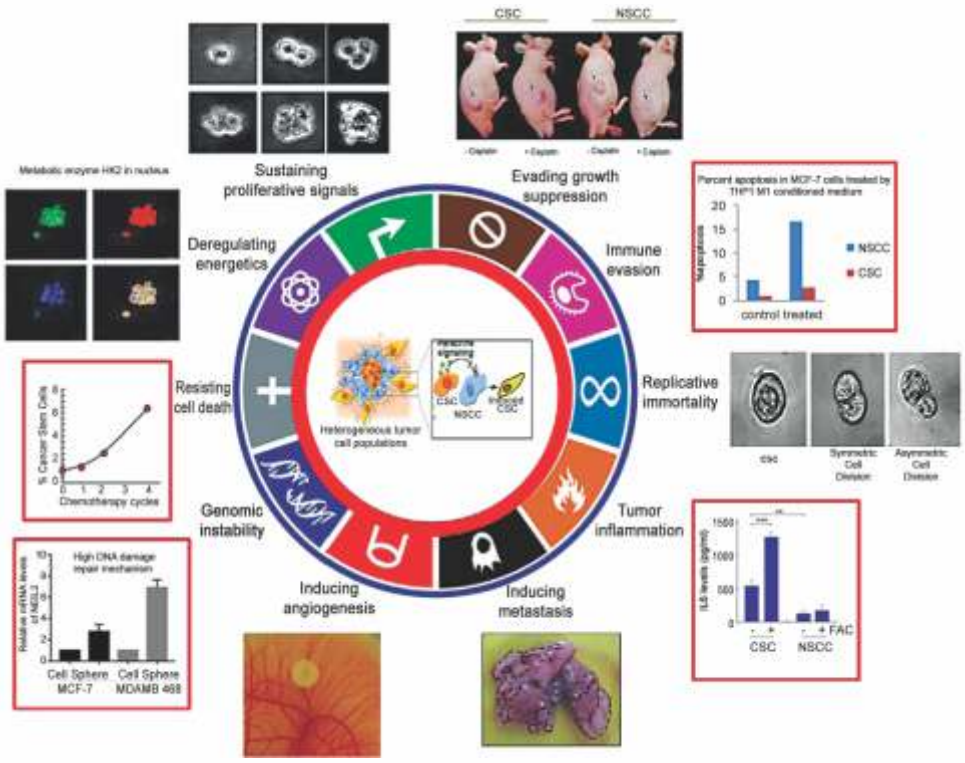


Figure-1 illustrates the key findings of the laboratory of Tanya Das demonstrating cancer stem cells as the 'Master Regulators' of all the 'Hallmarks of Cancer' thus establishing cancer as a 'Stem Cell Disease'

generation of vulnerable non-stem cancer cells (NSCCs) but also convert NSCCs to CSCs *via* paracrine signaling to increase drug-resistant CSC pool and escape chemo-insult.

- Her work for the first time demonstrated a non-metabolic nuclear role of the glycolytic enzyme Hexokinase II in stemness generation.
- Furthermore, she has defined the role of CSCs in creating pro-tumor immunity, which might be the reason behind cancer immunotherapyfailure.
- She has also identified a hitherto unknown unconventional Tregulatory cell (uTreg) population from cancer patients' blood that might become a diagnostic marker of cancer.
- After establishing cancer as a 'Stem Cell Disease' (Figure 1), she successfully sensitized CSCs by repurposing FDA-approved drugs, e.g., aspirin, phytochemicals like curcumin and homeopathic remedies like thuja.
- Besides, she putatively identified three novel microRNAs, which target various stemness and drug-resistance factors in CSCs. Prof. Das is now employing these microRNAsin a novel *in vivo* micro RNA delivery system for targeting CSCs and ultimately attenuating tumor development and progression.

Future Research Plans

- Delineating the mechanism underlying the nuclear role of, Hexokinase II, a major enzymeof aerobic glycolysis Warburg Effect) in CSCs
- Mapping the mechanisms of CSC-guided reprogramming of host's immune system
- Intervening target molecules/pathways identified by repurposing drugs/vitamins or by small molecule inhibitor(s), alone or with chemo-/immunotherapy
- Characterization of a durable and prolific cancer cell type from chemotherapy-treated non-metastatic breast cancer patients' blood whichhas the prospect of extensive use in scientific research.

Publication

1. Sengupta P, Bhattacharya A, Sa G, Das T, Chatterjee S (2019) Truncated G-quadruplex Isomers Cross-talk with the Transcription Factors to maintain Homeostatic Equilibria in c-MYC Transcription. *Biochemistry,* 58:1975-1991. doi: 10.1021/acs.biochem.9b00030.

Book Chapters / Invited Reviews

- Paul S, Dutta A, Basak U, et al (2019) .Cancer stem cell fate determination: a nuclear phenomenon. *The Nucleus*.https://doi.org/10.1007/s13237-019-00281-4.
- Guha D, Banerjee S, Mukherjee S, Dutta A and Das T (2019). Reactive oxygen species: Friends or foes of lung cancer? In *Oxidative Stress in Lung Diseases*. (Eds.ChakrabortiS, NarasimhamP, GhoshR, GangulyNK and Chakraborti T)Springer Nature Singapore Pvt. Ltd.,Vol-2.

Invited Talks

Delivered Invited Lecture at the *7th Federation of Immunological Societies of Asia-Oceania Congress (FIMSA 2018)* at Bangkok, Thailand.

Invited as a Key Speaker at the BIT's 16th Annual Conference on *International Drug Discovery Science and Technology*, held in Boston, USA.

Delivered talk as an Invited Faculty at the *International Conference of Asian Society of Mastology* held in Maldives.

Delivered *P. B. Rama Rao Memorial Award Lecture* of Society of Biological Chemists, India, at Manipal, India

Invited as a Resource person and to deliver Special Lecture at the *International Seminar on Homeopathy and Auxiliary Therapy of Oncology* held in Nasik, India.

Delivered plenary lecture as a Resource Person at the *Refresher's Course* of Dept. of Physiology, Calcutta University, Kolkata, India.

Invited to deliverthe *4thRatnaSom Memorial Lecture* at Jogomaya Devi College, Kolkata, India

Invited for delivering lecture at the *38th Annual Convention of Indian Association for Cancer Research* at Chandigarh, India.

Delivered Plenary Lecture at the International Conference of Pysiologfical Society of India *Physicon 2018* held at Sreerampore College, India.

Extramural Funding

- DST-SERB project entitled '*Role of cancer stem cells in tumor neo-angiogenesuis: A mechanistic study*'; 5th March 2018 - 4th March 2021; Rs. 48,76,800.00.
- DBT multi-institutional SyMec project (Director, BI is Co-ordinator) entitled '*Multi-dimensional ….. cluster approach*'; 2017 -2021; Rs. 14,05,32,000.00 (for Bose Institute).

Awards / Honours / Memberships

P. B. Rama Rao Memorial Award of Society of Biological Chemists, India.

Conference(s) / Workshop(s) : Indian & International: 9

Department of Physics

Introduction

Department of Physics has been an integral part of the Institute from the very begining and evolved along with the Institute. Though founder himself was involved mainly in his biological experiments, the Physics Department was involved in both theoretical as well experimental studies of different aspects, such as, propagation of radio waves in the ionosphere, propagation of supersonic wave in different media, study of nuclear disintegration, radioactivity and Cosmic Rays. Presently the research in the department is focused mainly in five areas namely, (a) Complex Systems and Statistical Physics (b) Nanoscience and advanced materials (c) Quantum Information and Foundation (d) Nuclear Physics and (e) High Energy and Astroparticle Physics.

Faculty Members

Prof. Swapan Kumar Saha, Professor (Superannuated on 31.01.2019); Dr. Sanjay Kr. Ghosh, Professor and Chairman; Dr. T.P. Sinha, Professor; Dr. Somshubhro Bandyopadhyay, Professor; Dr. Rajarshi Ray, Professor; Dr. Dhruba Gupta, Professor; Dr. Supriya Das, Associate Professor; Dr. Sidharth Kr. Prasad, Assistant Professor; Dr. Saikat Biswas, Assistant Professor; Dr. Achintya Singha, Associate Professor; Dr. Soumen Roy, Associate Professor; Prof. Barun Kr. Chatterjee, Sr-Professor (Superannuated on 30.11.2018); Dr. Parthasarathi Joarder, Associate Professor (Superannuated on 31.12.2018).

Senior Scientist

Prof. Probir Roy, INSA Senior Scientist; Prof. Sushanta Dattagupta, INSA Senior Scientist; Prof. Dipankar Home, NASI Senior Scientist.

Staff Members

Dr. Subhasis Banerjee, Technical Officer I; Shri Subrata Das, Technical Officer; Shri Sujit Kr. Basu, UDC-I; Shri Kaushik Maiti, Senior Laboratory Assistant; Shri Kanak Baran Hazra, UDC I; Shri. Shyam Sundar Mallick, Technical Officer I; Shri. Manas Datta, Technical Officer I; Smt. Rita Chakrabarty, UDC I; Shri Raj Kumar Mourya, Helper E; Shri. Amar Nath Hela, Helper D; Shri Ranjit Das, Helper D; Sri Sankar Prasad Singha, Accounts officer (Superannuated on 31.05.2018).

Students / RA / Project Assistant

Dr. Prasenjit Deb, CSIR RA; Dr. Susnata Seth, CBM MUCH RA; Dr. Alo Dutta, Research Associate I; Mr. Rathijit Biswas, Institute Fellow (SRF); Mr. Pratapaditya Bej, Institute Fellow (SRF); Ms. Sananda Raychaudhuri, Institute Fellow (SRF); Mr. Som Kanjilal, Institute Fellow (SRF); Mr. Abhishek Banerjee, Institute Fellow (SRF); Ms. Sumana Bhattacharyya, CSIR Ad-hoc (SRF); Mr. Souradeep Sasmal, DST Inspire (SRF); Ms. Pooja Bhattacharjee, DST Inspire (SRF); Ms. Pracheta Singha, DST Inspire (SRF); Mr. Deeptak Biswas, UGC Adhoc (SRF); Mr. Debarshi Das, UGC Adhoc (SRF); Ms. Trishna Bhattacharyya, Institute Fellow (SRF); Mr. Arkaprabha Ghosal, Institute Fellow (SRF); Mr. Kaushik Naskar, CSIR Ad-hoc (JRF); Md. Asif Bhatt, DST Inspire Fellow (JRF); Ms. Debjani Banerjee, DST Inspire Fellow (JRF); Mr. Arindam Sen, DST Inspire Fellow (JRF); Ms. Shreya Roy, Institute Fellow (JRF); Mr. Pratik Ghosal, Institute Fellow (JRF); Mr. Prottoy Das, Institute Fellow (JRF); Mr. Sayak Chatterjee, Institute Fellow (JRF); Mr. Abhi Modak, Institute Fellow (JRF); Md. Sariful Sheikh, Inspire Fellow (SRF); Mr. Ram Awadesh Kumar, CSIR Adhoc (SRF); Mr. Moumin Rudra, UGC Adhoc (SRF); Mr. Tushar Kanti Bhowmik, Inspire Fellow JRF; Mr.

Sreyan Raha, Institute SRF; Ms. Kabita Kundalia, Institute SRF; Sk. Mustak Ali, Institute SRF; Mr. Ranjan Sutradhar, Inspire Fellow; Ms. Sumana Gope, Inspire Fellow JRF; Mr. Himadri Sekhar Tripathi, Inspire Fellow JRF; Mr. Deep Nath, CSIR Adhoc JRF; Mr. Subhankar Maity, UGC Adhoc JRF; Ms. Sahanaj Aktar Banu, Inspire Fellow JRF; Ms. Chumki Nayak, Inspire Fellow JRF; Mr. Suvadip Masanta, CSIR Adhoc JRF; Saswata Halder, Sanjoy Mukherjee, Saptarshi Sinha, Arup Roy, Dr. Abhishek Atreya, Dr. Manindra Sinha, Shib Shankar Singha, Tara Shankar Bhattacharyya.

Research Scientist

Dr. Subhasis Roy, Research Scientist (Assistant Professor of C.U.)

DR. ACHINTYA SINGHA

Associate Professor

Name of the Participants

Mr. Shib Shankar Singha, SRF; Mr. Tara Shankar Bhattacharya, SRF; Mr. Sreyan Raha, SRF, Ms. Chumki Nayak, JRF; Mr. Suvadip Masanta, JRF.

Background

The study of nanomaterials has stimulated a new enthusiasm in the field of science and technological applications. Most of the physical and chemical properties of a matter change, often quite drastically, at the nanoscale. Therefore, low dimensional materials act as a laboratory to study the fascinating phenomenon in the sub-micron regime. Moreover, nanostructure materials show novel electronic and vibrational properties that strongly depend on the sample constitution and size and external perturbations. Hence, it is possible to fabricate devices with well-defined optoelectronic properties by varying size, material composition, doping or by external influences. So, the basic research on nanomaterials not only meets the desire of scientists but also generates the foundation for future technological applications. Raman spectroscopy is a powerful tool for characterization and to explore basic science behind many novel phenomena in physics. The technique is highly sensitive to external and internal perturbations like size, electric fields, temperature,

pressure and strain. It provides immense information such as the interaction of phonon with various other quasiparticles (e.g., electrons, magnons, orbitons, etc.), structural phase transition, isostructural transitions, topological quantum phase transitions, thermal conductivity, defects, carrier concentration, strain etc. We are interested in studying the effect of various types of internal and external influences in nanostructured solids using vibrational and optical spectroscopy.

Aims and Objectives

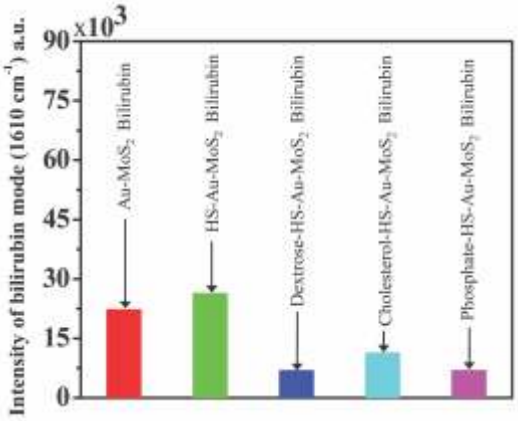
Our current research involves:

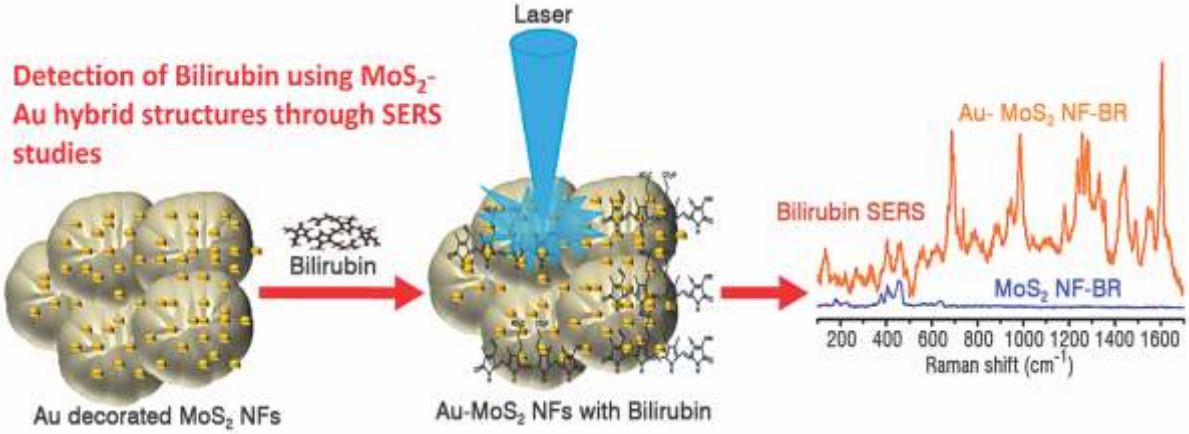
- Study of lattice dynamics in low dimensional systems
- Understanding interplay between phonons and other quasiparticles
- Light matter interaction at low dimension
- Surface Enhanced Raman Scattering (SERS)

Work Achieved

Au NPs functionalized 3D-MoS_2nanoflower: An efficient matrix for molecule sensing

Molybdenum disulfide (MoS_2), an important material of TMD family, is attracting increasing attention in molecular sensing due to its unique electronic and optical properties. Functionalization of the MoS_2 with noble metal nano particles is an effective method to modulate its physical properties and makes it more appropriate for biosensing applications. This work shows the application of gold nanoparticles (AuNPs) decorated MoS_2 nanoflowers (Au-MoS_2 NFs) as efficient molecule-sensor. The abundant 'hot-spots' created by AuNPs due to localization of electromagnetic field provides the Au-MoS_2 hybrid structure as an excellent substrate for chemical sensing through Surface Enhanced Raman Scattering (SERS). The composite was used to detect free bilirubin, from





pico-molar level to hyperbilirubinemia state. The substrate shows excellent selectivity and reliability while sensing free bilirubin performed in human serum in the presence of crucial interferences such as dextrose, cholesterol and phosphate. (*Biosensors and Bioelectronics 119 10 (2018)*).

Future Research Plans

- Understanding exotic phases in low dimensional systems at extreme conditions (e.g. Low / high temperatures, high pressures, magnetic field, and electric field)
- Tuning Light matter interactions in low dimensional
- Valleytronics
- Development of energy storage devices

Publications

1. Bhattacharya T S, Maitra P, Bera D, Das K, Bandyopadhyay P, Das S, Bhar D S, Singha A, Nandy P (2019) Investigation of the Origin of Voltage Generation in Potentized Homeopathic Medicine through Raman Spectroscopy, *Homeopathy*, 108, 121 (7pp) (I. F.: 1.524)
2. Mandal S K, Dutta K , Pal S, Mandal S, Naskar A, Pal P K , Bhattacharya T S, Singha A, Saikh R, De S, Jana D (2019) Engineering of ZnO/rGO nanocomposite photocatalyst towards rapid degradation of toxic dyes, *Materials Chemistry and Physics*, 223, 456 (10pp) (I. F.: 2.781)
3. Mondal A, Pal S, Sarkar A, Bhattacharya T S, Das A, Gogurla N, Ray S K, Kumar P, Kanjilal D, Devi K D, Singha A, Chattopadhyay S, Jana D (2018),Raman spectroscopic analysis on Li, N and (Li, N) implanted ZnO, *Materials Science in Semiconductor Processing*, 80, 111 (7pp) (I. F.: 2.722)
4. Ray S, Sen S, Das A , Bose A, Bhattacharyya A , Das A, Chattopadhyay S , Singha S S, Singha A, Patra H K, Dasgupta A K (2018) Bioelectronics at graphene–biofilm interface: Schottky junction formation and capacitive transitions, *Medical Devices & Sensors*, 1, 1 (12pp)
5. Ratha BN, Kar RK, Kalita S, Raha S, Singha A, Garai K, Mandal B, Bhunia A (2019) Sequence specificity of amylin-insulin interaction: a fragment-based insulin fibrillation inhibition study, *Biochimica et Biophysica Acta (BBA)-Proteins and Proteomics*, 4, 405 (11pp) (I. F.: 2.848)
6. Roy A, Singha SS, Majumder S, Singha A, Banerjee S, Satpati B (2019) Electroless Deposition of Pd Nanostructures for Multifunctional Applications as Surface Enhanced Raman Scattering Substrate and Electrochemical Non-Enzymatic Sensor, *ACS Applied Nano Materials*, 2, 2503 (12pp)
7. Singha SS, Mondal S , Bhattacharya TS, Das L, Sen K, Satpati B, Das K, Singha A (2018), Au nanoparticles functionalized 3D-MoS_2 nanoflower: An efficient SERS matrix for biomolecule

sensing, *Biosensors and Bioelectronics*, 119, 10 (8pp) (I. F.: 9.518).

Invited Talks

- Delivered invited talk in "7th International Conference on Perspectives in Vibrational Spectroscopy (ICOPVS-2018) held at Bhabha Atomic Research Centre in Mumbai, India during November 25 - 29, 2018.
- Delivered invited talk in "International Conference on Complex & Functional Materials (ICCFM-2018)" organized by S. N. Bose National Centre for Basic Sciences, Kolkata, India in the occasion of 125th birth year of Prof. S. N. Bose (Bose-125) during 13th to 16th December 2018 held at Biswa Bangla Convention Centre, Kolkata.
- Acted as resource person and delivered a talk in 'Students' Training Programme at Bose Institute from 18th to 20th December 2018

Extramural Funding

- "Fabrication of infrared photo-detector based on 2D systems and tuning the detection window by coupling with nanostructures" (15th Sept. 2018-14th Sept. 2021) SERB (DST), India. Total Project Value: Rs. 65,1871/-

Conference(s) / Workshop(s)

- Poster presentation at International Conference on the Physics of Semiconductors (ICPS 2018) held during 29th July to 3rd August, 2018 in Montpellier, France.

DR. DHRUBA GUPTA

Professor

Name of the Participants

Dr. Mandira Sinha, RA; Sk. Mustak Ali, SRF; Ms. Kabita Kundalia, SRF; Mr. Subhankar Maity, JRF; Ms. Sahanaj Aktar Banu, JRF.

Collaborator

Dr. Swapan Kumar Saha, Professor, BI (Superannuated on 31/01/2019).

Background

I work in the area of nuclear astrophysics with rare isotope beams. Recent advancements in nuclear science allow us to study very neutron and proton rich exotic nuclei (rare isotopes) at the limits of stability. At present, a world-wide effort is put into studying nuclear structure, reactions and astrophysics using rare isotope beams in accelerators. Several new facilities as well as upgrades are coming up in many countries including India. We are involved in experiments at CERN, Switzerland and GANIL, France with the new exotic isotopes that we expect will lead to a comprehensive understanding of nuclei and the origin of the elements in the universe. It is also very important to develop robust theoretical frameworks to explain new results from the increasingly important accelerator based experiments with exotic nuclei. We carry out both theoretical and experimental work on such nuclei away from the line of -stability.

Department of Physics

Aims and Objectives

My research involves some key reactions in nuclear astrophysics. The Big Bang Nucleosynthesis (BBN) theory is consistent with observation for the abundance of light nuclei except for Lithium. For ^{7}Li, an anomaly by a factor of four is observed and is known as the Cosmological Lithium problem, unsolved for decades. My work involves searching for unknown resonances in nuclear reactions to solve this problem. My interest also includes radiative capture reactions ^{13}N(p,)^{14}O and ^{8}Li(n,)^{9}Li in relation to the transit from Carbon-Nitrogen-Oxygen (CNO) cycle to the hot CNO cycle occurring in several astrophysical situations and inhomogeneous nucleosynthesis respectively. Now, to extract new information from the experimental data involving exotic nuclei, sophisticated theoretical frameworks are essential. To this end, we developed a method to study unknown resonances in unstable and unbound nuclei by using supersymmetric quantum mechanics (SQM). The resonance state energies obtained were found to be in excellent agreement with the experimental values.

Work Achieved

We carried out an experiment in November 2018, in relation to the Cosmological ^{7}Li problem. This involved the destruction of ^{7}Be, the main source of ^{7}Li during Big Bang. At CERN-HIE-ISOLDE, Geneva, Switzerland, we used a 35 MeV ^{7}Be beam on CD_2 target to measure the ^{7}Be(d,p)^{8}Be* reaction. A Si-detector array in a pentagon geometry was used. This is the first project from an institute in India to be carried out at CERN-HIE-ISOLDE. To complement our experimental findings we utilized a theoretical framework developed by us using SQM to study resonances in weakly bound and unbound nuclei. Preliminary analysis show new resonances in the above nuclear reaction. Experimental data on ^{7}Be + ^{208}Pb target is also being analyzed to give an estimate for future

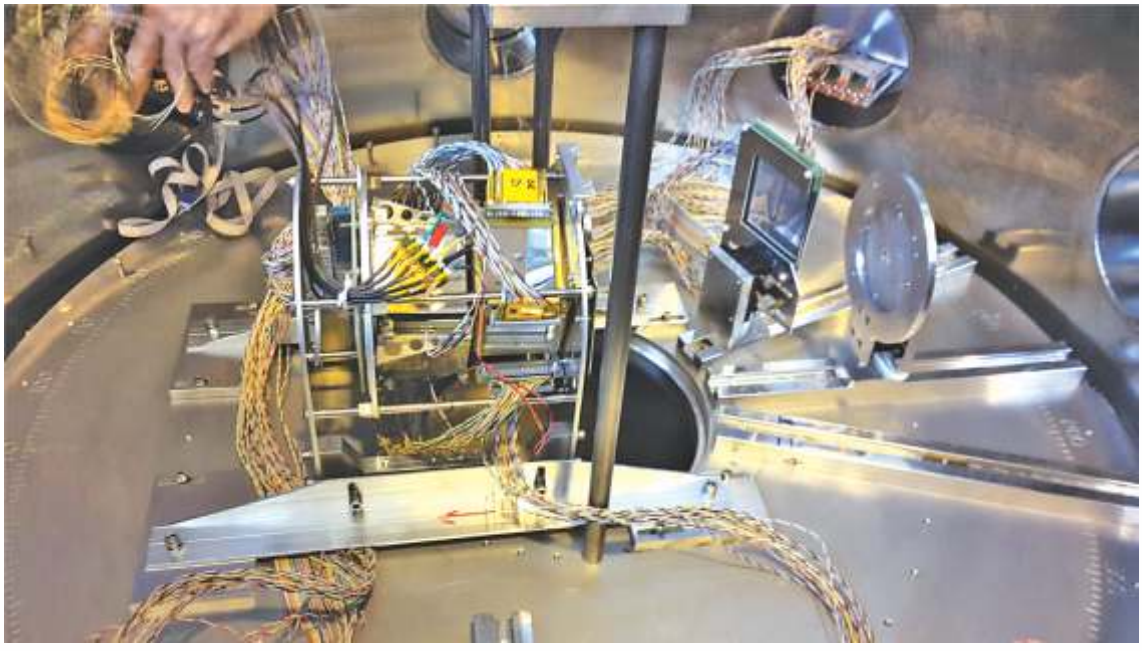


Fig. 1 Experimental setup at CERN-HIE-ISOLDE to study the Cosmological ^{7}Li problem (November 2018)

experiments on the breakup of ^{7}Be. This will throw light on the production channel of ^{7}Be in the search for a solution to the Cosmological Lithium problem. In addition, substantial progress on the data analysis of the n-p pairing experiment at GANIL was achieved. We are analyzing the rather difficult thin target data of ^{56}Ni(p,d) reaction at Bose Institute in the NPTool framework.

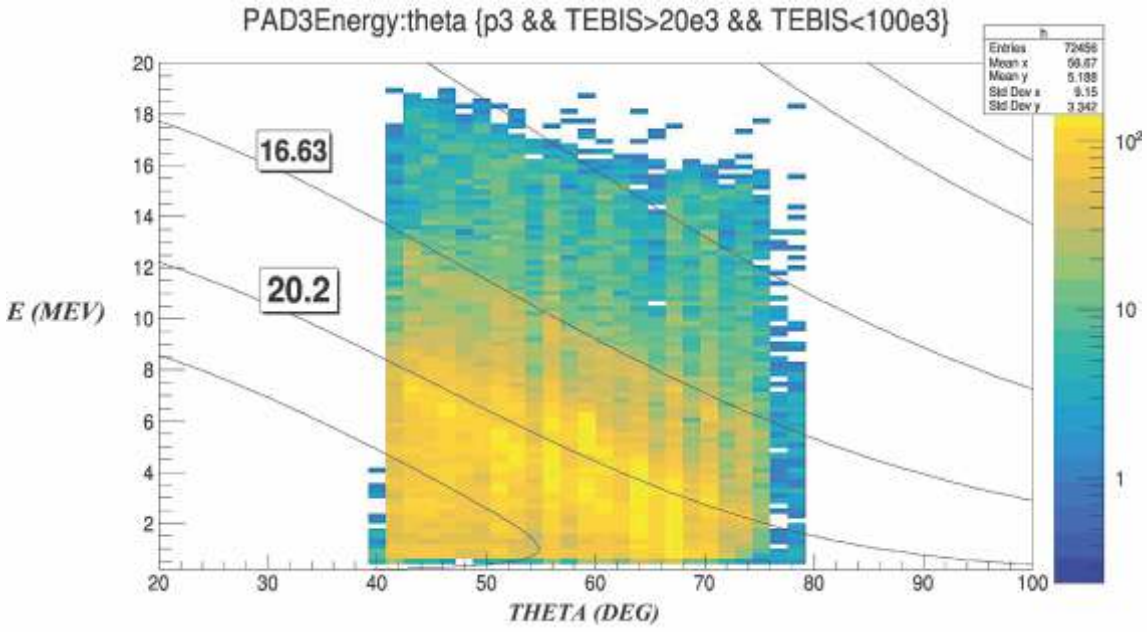


Fig. 2 Resonance states from preliminary analysis of the experimental data ^{7}Be(d,p)^{8}Be*

Future Research Plans

There is also a variant scenario known as inhomogeneous BBN, where the baryons are spatially unevenly distributed in some local pockets. It is difficult to evaluate the merits of inhomogeneous nucleosynthesis versus standard BBN, because the rates of several important reactions are either not measured or not well established. We plan to study ^{8}Li(n,)^{9}Li from Coulomb breakup of ^{9}Li. The other important reaction to study is ^{13}N(p,)^{14}O through Coulomb breakup of ^{14}O in the context of the hot CNO cycle. Such experiments can be performed only in rare isotope accelerators like CERN and GANIL. We also plan to study resonance states of ^{8}Be, ^{9}B, ^{12}C and scattering cross sections of exotic nuclei utilizing our well established theoretical technique using supersymmetric quantum mechanics.

Invited Talk

"Search for higher excited states of ^{8}Be* to study the cosmological ^{7}Li problem" ISOLDE, CERN, Geneva, Switzerland, November 21, 2018.

Extramural Funding

Principal Investigator of project titled : "Astrophysical S-factor from nuclear reactions with a rare isotope beam of ^{7}Be" ISRO, 3 years, 39.8 lakhs (termination date 05.08.2018).

Conference(s) / Workshop(s)

1. ISOLDE Workshop and Users Meeting 2018, CERN, Geneva, Switzerland, December 5-7, 2018
   Title : The d + ^{7}Be reaction to study the cosmological lithium problem
   Authors : M. Ali, D. Gupta, K. Kundalia, S.K. Saha, O. Tengblad, J.D. Ovejas, A. Perea, I. Martel, J. Cederkall, J. Park, S. Szwec

2. ISOLDE Workshop and Users Meeting 2018, CERN, Geneva, Switzerland, December 5-7, 2018
   Title : Coulomb dissociation of ^{14}O in the context of hot CNO cycle
   Authors :K. Kundalia, S.K. Saha, M. Ali, D. Gupta

3. EURORIB 2018, Giens, France, May 27 - June 1, 2018
   Title: Transfer and breakup reactions with ^{7}Be to study the cosmological lithium problem
   Authors: D. Gupta, S.K. Saha

4. EURORIB 2018, Giens, France, May 27 - June 1, 2018
   Title: The ^{8}Li(n,) cross section via Coulomb dissociation of ^{9}Li
   Authors: S.K. Saha, D. Gupta

DR. RAJARSHI RAY

Professor

Name of the Participants

Pratik Ghoshal, Deeptak Biswas, Sumana Bhattacharyya, Pracheta Singha, Abhishek Atreya

Collaborators

Ramaprasad Adak, Abhijit Bhattacharyya, Sanjay K. Ghosh, Soumitra Maity, Sibaji Raha, Kinkar Saha, Subhasis Samanta, Sudipa Upadhaya

Background

Formulating a reliable model for the phases of strong interactions

As is well known, there are four fundamental forces in nature – gravitation, electro-magnetism, weak and strong. While the first three are easily perceptible, the strong interactions are not so because they are effective only at or below a few femtometer (i.e. nuclear) length scales. This force holds the protons and neutrons together inside the nucleus. However at sub-femtometer scales new fundamental particles – the quarks and gluons are the active degrees of freedom that interact via strong interactions. The quarks and gluons are however bound within the femtometer distances due to the phenomenon of confinement of the intrinsic charges of strong interactions, called as 'colour' charges.

At temperatures ~ 10^12 K and / or at matter densities ~ 10^17 Kg/m^3, the strong interactions are not restricted to femtometer distances. Then it could be possible to see colour charges flowing over macroscopic distances. This state of matter is known as Quark Gluon Plasma. Such high temperatures possibly existed in the early universe and such high densities may now exist in the core of super-massive stars like the neutron stars

The first principle theory of strong interactions is Quantum Chromodynamics. If the interaction strength is not so strong one can perform analytic perturbative analysis. But the interesting phenomenon of transition of colour confined hadronic matter to the deconfined quark gluon matter occurs when the interaction is really strong. From first principles it is an extremely complicated, involved and time consuming problem to solve in the so called lattice formulation. It would therefore be useful to build a model system that mimics the relevant physics of the system and yet remain light on the required resources. This is the direction that we pursue in our group.

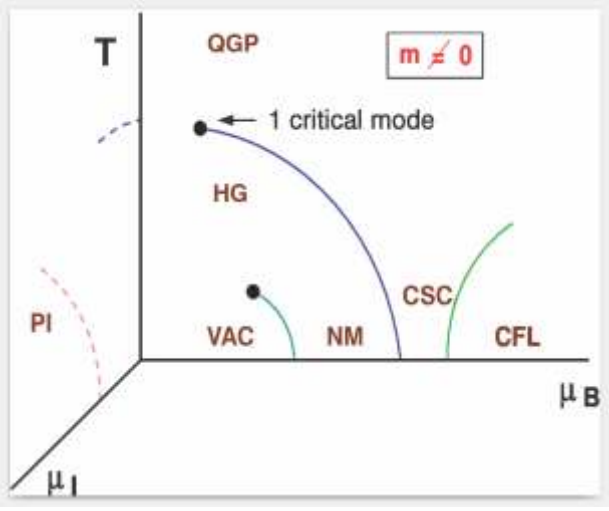


Figure illustrating the essence of our research work

The figure illustrates the phase diagram of strongly interacting matter. T is the temperature axis and the other two are the baryon and isospin chemical potential axis respectively. The phase structure is quite rich with different phases and phase boundaries, crossover regions, critical end points as has been investigated in various models. Here HG denotes the hadron gas phase and QGP denotes the quark gluon plasma phase discussed previously

Aims and Objectives

Our aim is to to study the thermodynamic properties for strong interactions. Our current objectives are:

- Study the limitations of various existing models by contrasting them with certain available first principle results as well as by confronting with the experiments
- Build a reliable model that can accommodate a higher number of physical features of strong interactions
- Use these models for the study and characterization of strongly interacting systems formed in the ultra-relativistic heavy-ion collision experiments, as well as for the evolution of the early universe and super-massive stars.

Work Achieved

- Developed the Polyakov Loop enhanced Nambu-Jona-Lasinio (PNJL) model for studying the chiral symmetry and colour deconfinement properties.
- Investigated aspects of hadronic physics using the Hadron Resonance Gas model.

- Developed a hybrid approach for hadronic and quark gluon matter over a considerable range of temperatures.

Future Research Plans

- Develop a consistent description of phases of strong interaction with *beyond mean field* approach of the PNJL model.
- Explore strongly interacting matter out of thermodynamic equilibrium.

Students Awarded Ph.D.

- Soumitra Maity (CU, 2019) Understanding the Properties of Strong Interactions in Effective QCD Models.
- Sudipa Upadhaya (CU, 2019) Understanding the Signatures of Phase Transition in Strongly Interacting Systems Through Fluctuations And Correlations.

Publication

1. Bhattacharyya Abhijit, Ghosh Sanjay K, Maity Soumitra, Raha Sibaji, Ray Rajarshi, Saha Kinkar, Samanta Subhasis and Upadhaya Sudipa (2019) Thermodynamics of strongly interacting matter in a hybrid model, *Phys. Rev.* C99 no.4, 045207.

Invited Talks

- *Thermodynamics of strongly interacting matter in a hybrid model,* in the Workshop on Effective Field Theory at Finite Temperature, at TIFR, Mumbai, during September 1-2, 2018.
- *Thermodynamics of strong interactions,* in the Conference on Frontiers in Particle Physics and Cosmology, at the University of Hyderabad, during January 23-25 January 2019.

Extramural Funding

- Cosmic Ray Cloud Connection, IRHPA project from DST: IR/S2/PF-01/2011 dt. 26.06.2012 (for 05 years, extended).

DR. SAIKAT BISWAS
Assistant Professor

Name of the Participants

Shreya Roy, Sayak Chatterjee, Arindam Sen.

Collaborators

Shubham Jaiswal, Rituparna Banerjee, IIT-ISM, Dhanbad; Krishna Nivedita G, IISER Thiruvananthapuram; Aayushi Paul, University of Calcutta; Abhisek Roy, Central University, Jharkhand; Debonita Saha, St. Xavier's College.

Background

I am working on the Physics of Particle Detectors. A detector is used to detect charged particles and uncharged radiations and to measure its mass, momentum, energy etc. There are basically three kinds of detectors in the world; the gaseous detectors, the scintillation detector and the solid-state detectors. I am working on the first two categories.

Bose Institute is contributing on the research program of upgradation of the ALICE Time Projection Chamber (TPC) with Gas Electron Multiplier (GEM) and on the Muon Detection System (CBM-MUCH) of CBM experiment. As both these detection systems will use GEM based chambers, we are working on the R&D of these detectors. This R&D program includes research on Resistive Plate Chamber (RPC), Gas Electron Multiplier (GEM), Straw tube detector, Single Wire Chamber and Multi Wire Proportional Counter

(MWPC).We are also working on the fast plastic scintillator detectors for imaging and detection of cosmic ray.

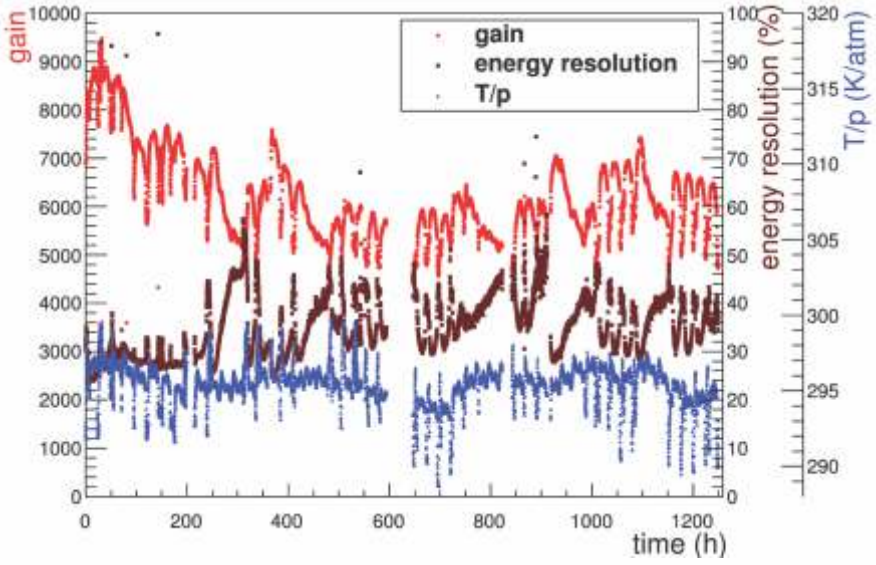
Aims and Objectives

Our main research interests based on the physics of the ageing of gaseous detectors, studyof the rate handling capability of straw tube detector, development of a new type of single gap RPC using very low-resistive material. We have started using scintillator detector for imaging.

One large component of our program is research on organic and inorganic Scintillation detectors for detection of cosmic rays.

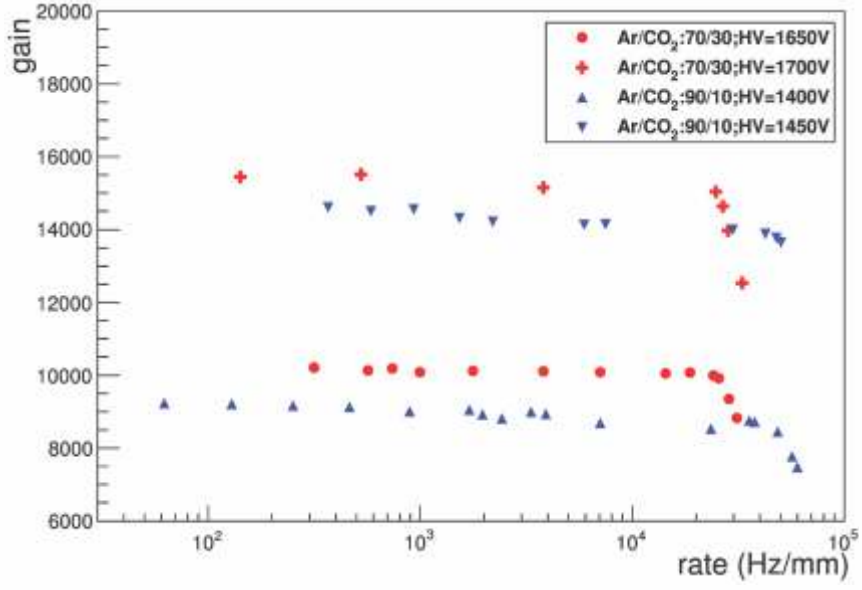
Work Achieved

Measurement of the spark probability of GEM detector for the CBM muon chamber (MUCH) has been performed. Systematic measurements and the long-term stability test of the gain and the energy resolution of GEM detectors are being carried outand no degradation observed.



Variation of gain, energy resolution and ratio of temperature and pressure as a function of time for GEM detector.

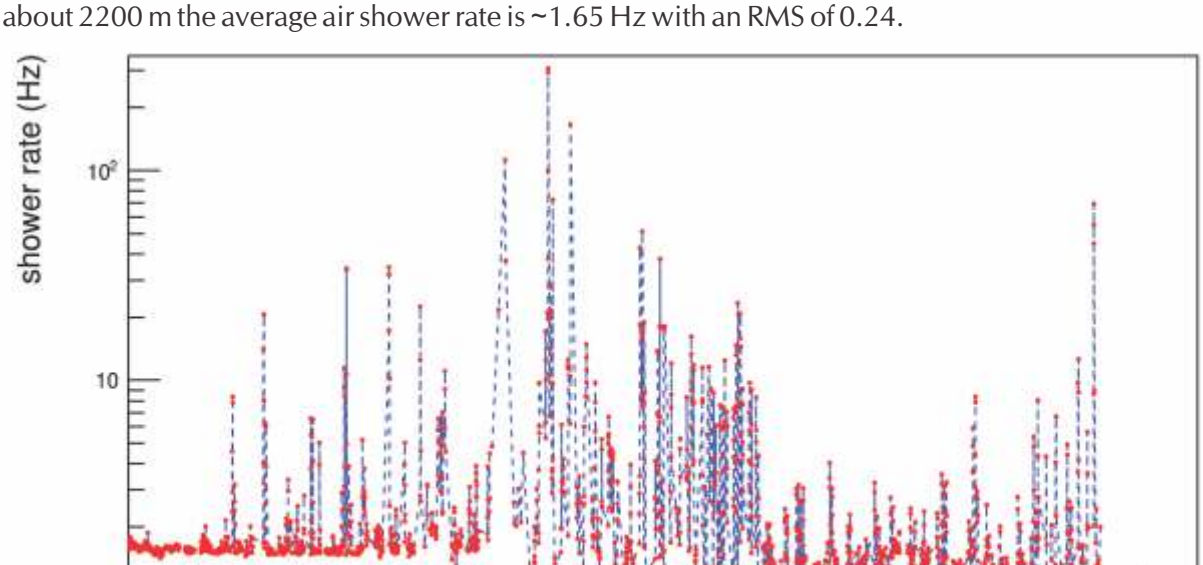
Study of performances of a straw tube detector with high rate has been done. The gain and the energy resolution remain constant up to a rate of about 2×10^4 Hz/mm and 3.2×10^4 Hz/mm for Ar/CO_2 70/30 and 90/10 respectively.



Variation of gain as a function of rate for straw tube detector.

An array of seven plastic scintillator detectors has been commissioned for detection of cosmic ray air showers at an

altitude of about2200 m above sea level in the Himalayas. The detector system is continuously measuring the number of cosmic ray showers. From this array it has been found that at an altitude of about 2200 m the average air shower rate is ~1.65 Hz with an RMS of 0.24.



Cosmic ray shower rate at Darjeeling as a function of time.

Future Research Plans

- R&D of GEM detectors and straw tube for the CBM experimentwill continue. We would like to build detectors likestraw tubewith metal cylinder for CBM.
- Development of ageing measurement set-up for gaseous detector. This will be a general facility of ageing measurement of all kind of gaseous detectors.
- We are in a process to build RPC with indigenous materials for CBM-MUCH. We would also like to do a research on used gas for RPC as now a day people are thinking to use Freon-less gas in RPC. Study of rate handling capacity of RPC.

Publications

1. Aggarwal M.M. *et al* (2018) Particle identification studies with a full-size 4-GEM prototype for the ALICE TPC upgrade, *Nuclear Instruments and Methods in Physics Research* A 903, 215- 223.
2. Nag D, Biswas S , Chattopadhyay S, Das S, Dubey A K , Ghosh C, Kumar A, Prasad S K and Saini J (2018) Design and Fabrication of a Controlled Water Based Cooling System for CBM Muon Chamber;; Springer International Publishing AG, part of Springer Nature 2018, XXII DAE High Energy Physics Symposium, *Springer Proceedings in Physics* 203, 893-895.
3. Patra Rajendra Nath, Singaraju Rama N, Biswas Saikat, Viyogi Yogendra P, Nayak Tapan K. (2018) Characteristic study of a quadruple GEM detector and its comparison with a triple GEM detector, *Nuclear Instruments and Methods in Physics Research* A 906, 37- 42.

4. Patra Rajendra Nath, Singaraju R N, Biswas S, Ahammed Z, Nayak T K and Viyogi YP(2018) Study of a Triple GEM Detector Operated with Different Argon Based GasSpringer International Publishing AG, part of Springer Nature 2018, XXII DAE High Energy Physics Symposium, *Springer Proceedings in Physics* 203, 821-823.

5. Patra Rajendra Nath, Singaraju R N, Biswas S, Nayak T K and Viyogi Y P (2018) Time Resolution and Characteristic Studies of MWPC Detectors with Argon Based Gas Mixtures; Springer International Publishing AG, part of Springer Nature 2018, XXII DAE High Energy Physics Symposium, *Springer Proceedings in Physics* 203, 509-511.

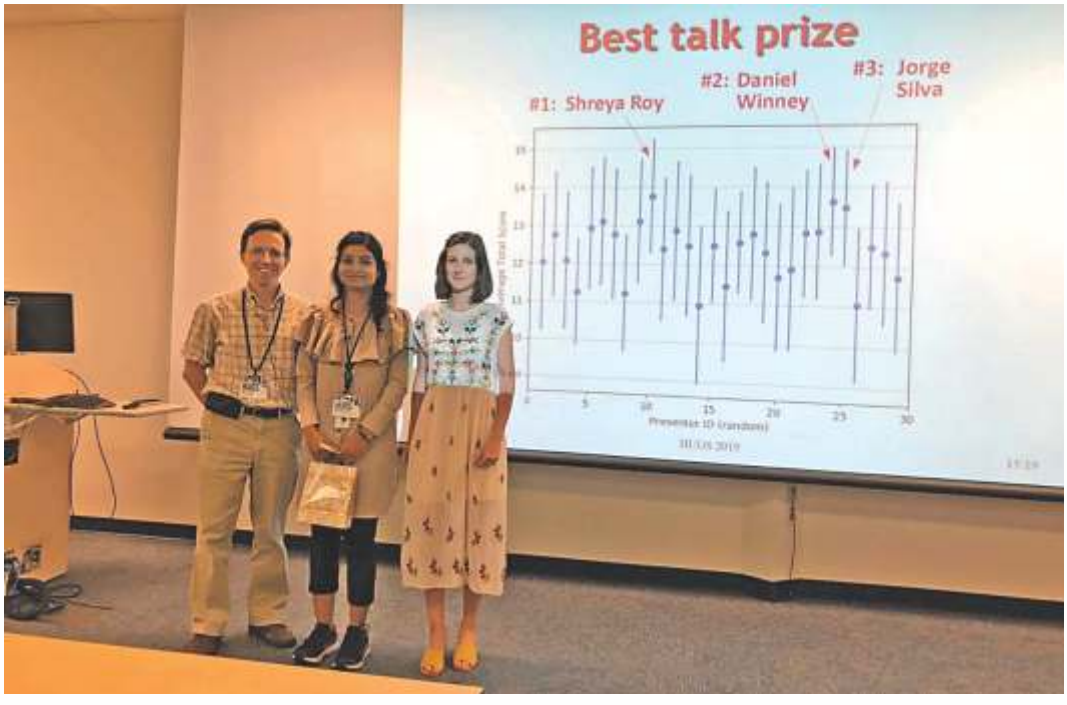
6. Roy S, Nandi N, Adak R P, Biswas S, Das S, Ghosh S K, Prasad S K, and Raha S (2018) Variation of gain and energy resolution with temperature and pressure of straw tube detector; *Proceedings of the DAE-BRNS Symposium on Nuclear Physics*. Volume 63, 1046-1047.

Book Chapters / Invited Reviews

Saikat Biswas, Supriya Das, Sanjay Kumar Ghosh Advanced Detectors for Nuclear, High Energy and Astroparticle Physics, *Proceedings of ADNHEAP 2017*; (Editors); Springer Proceedings in Physics 201, ISBN 978-981-10-7664-0.

Invited Talks

1. RD51 mini week, CERN, Switzerland, December 04-06, 2018.
   Title: Stability study of triple GEM detector with radioactive source.
2. FAIR week, Vigyan Samagam, Nehru Science Centre, Mumbai, 24-30 June, 2019.
   Title: Detectors for Physics and Medical Imaging: an introduction.



Department of Physics

Awards / Honours / Memberships

Ms. Shreya Roy, Bose Institute received the best talk prize in HUGS 19, Jefferson Laboratory, USA.

The title of her talk was "Overview of detectors for the Muon Chamber of CBM experiments at FAIR"

Conference(s) / Workshop(s)

1. Frontier Detectors for Frontier Physics (14th Pisa meeting on advanced detectors), La Biodala, Isola d'Elba, Italy, May 27- June 02, 2018.:6 Abstracts
2. RD51 mini week, CERN, Switzerland, December 04-06, 2018.
3. Organized the FAIR week at Vigyan Samagam, Nehru Science Centre, Mumbai along with Sayak Chatterjee and Arindam Sen.

DR. SANJAY K. GHOSH

Professor

Name of the Participants

Deeptak Biswas, Trishna Bhattacharyya

Collaborators

Ramaprasad Adak, Abhijit Bhattacharyya, Abhijit Chatterjee, Sanat k. Das, Soumitra Maity, Sibaji Raha, Kinkar Saha, Subhasis Samanta, Sudipa Upadhaya,

Background

Discovery of quarks as an underlying substructure of hadrons (baryons and mesons) in the mid 60's has opened up new directions of research in particle physics. Quarks are strongly interacting objects, Quantum Chromodynamics (QCD) being the theory of strong interaction. The interesting characteristics of quark is that their interaction strength increases with the separation between them while becoming very small, leading to free quarks, at smaller separations. This in turn implies that at very high temperature and/or densities the quarks will no longer be confined inside hadrons and one may envisaged a phase transition from hadronic to quark matter.

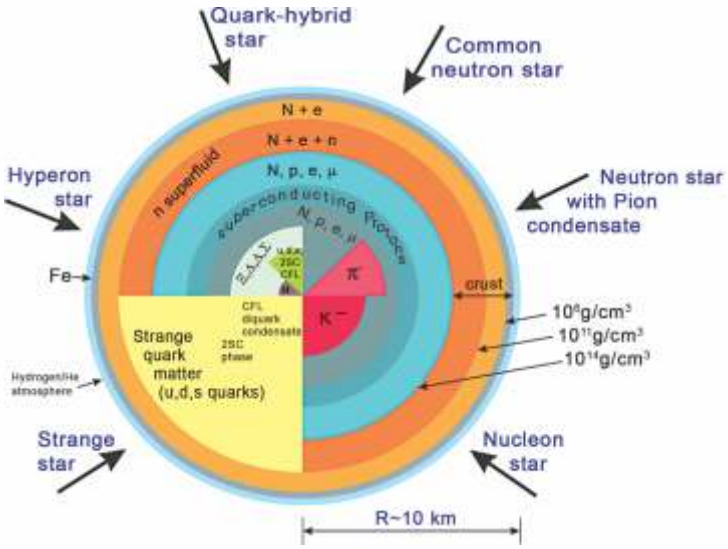
In nature such a phase transition must have occurred in early universe, few microsecond after big bang, when the universe was hot. On the other hand such a scenario may also occur inside the Neutron stars where baryon density is extremely high, temperature being low. Presently at LHC, CERN, heavy ion collision experiments are exploring this early universe scenario. The high density scenario will be explored in Facility for antiproton-ion research at GSI, Germany.

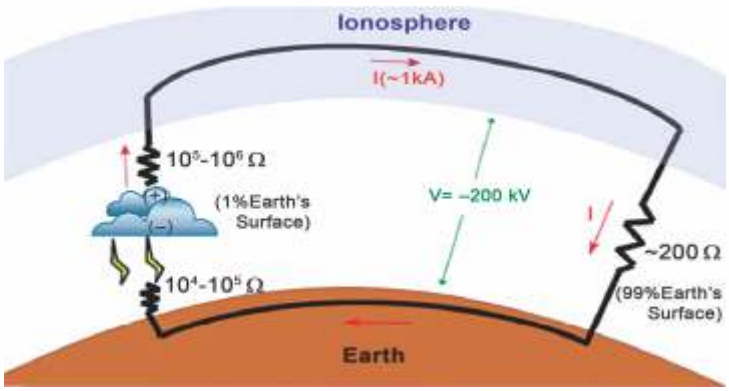
Theoretical studies also suggest that quark matter may also exist in the form of small lumps of low baryon number, usually called as strangelets. Theoretical

studies also suggest, that these objects may reach the earth's surface and can be detected in cosmic ray detectors.

I have been involved in the theoretical studies to understand the characteristics of strongly interacting matter and possible phase transition at high temperature and/or density. Experimental studies are also being conducted to detect the exotic components, such as, strangelets, in the cosmic ray air shower using passive nuclear track detectors.

Cosmic Rays are also an important part of the earth-ionosphere global electric circuit with thunderstorms acting as battery. Understanding of atmosphere electric field, its correlation with cosmic ray flux and atmospheric components such as aerosol optical depth etc. is another area of research, which I am pursuing presently.





Aims and Objectives

- Understanding the characteristics of strongly interacting system at high temperature and/or density using phenomenological models
- Understanding the nature of phase transition inside neutron stars and its observable implication
- Standardization of solid state nuclear track detectors for the search of rare events in cosmic ray air showers
- Understanding of atmospheric electric field variability, its correlation with cosmic ray flux, various atmospheric parameters and its connection with thunderstorm

Work Achieved

- Understanding of Shear viscosity and shear viscosity to entropy ratio for a strongly interacting system using phenomenological models.
- Understanding of the effect of magnetic field on the hadron yields using model
- Radiation background at various high altitude locations has been studied in prepration for rare event search in cosmic rays

- Two widely used methods of determining the etch-rate ratio in poly-ethylene terephthalate (PET) nuclear track detector are compared. Their application in different regimes of ion's energy loss is explained. A new calibration curve for PET is also presented.

Future Research Plans

- Theoretical understanding of forward physics to be explored experimentally in heavy ion collision experiments at LHC.
- Modeling of atmospheric electric field to understand its dependence/effect on other atmospheric parameters and now-casting of rain.

Publications

1. *Proceedings, Advanced Detectors for Nuclear, High Energy and Astroparticle Physics (ADNHEAP 2017) : Kolkata, India, February 15-17, 2017,* Saikat Biswas (ed.), Supriya Das (ed.), Sanjay Kumar Ghosh (ed.). 2018. Springer Proc.Phys. 201 (2018) pp.1232
2. Bhattacharyya R, Dey S, Ghosh Sanjay K, Jhingan Akhil, Maulik A, Patrizii L, Raha Sibaji, Syam D, Togo V (2018) *A comparative study of alternative methods to determine the response of poly-ethylene terephthalate nuclear track detector, Nucl.Instrum.Meth.* B434 (2018) 51-55.

Extramural Funding

- "Development of cost effective and portable electro-optical system for effective investigation of residual ambient gases using spark emission technology". (2019-2021). DST/TDT/DDP-07/2018(C)
- "Study of cosmic ray interaction and cosmic ray- aerosol cloud connection in the context of climate change" (2012 – continuing with extension) IR/S2/PF-01/2011

DR. SIDHARTH KUMAR PRASAD
Assistant Professor

Name of the Participants

Abhi Modak, JRF, Institute Fellow; Prottoy Das, JRF, Institute Fellow; Debjani Banerjee, JRF, DST Inspire Fellow.

External Collaborations

A Large Ion Collider Experiment (ALICE) at CERN, Geneva; Compressed Baryonic Matter (CBM) experiment at GSI, Germany

Background

Characterization of a novel/new state of matter with partonic degrees of freedom known as Quark Gluon Plasma (QGP), which is believed to be existed in the first few microsecond old universe, is one of the main goals of our research. Understanding (both qualitative and quantitative) of various properties of the QCD matter such as viscosity, thermal conductivity, diffusion coefficients etc is one of the open questions to be addressed through the study of QGP.

Creating such matter in the laboratory requires very high temperature ($\sim 10^{12}$ K) and is achieved by colliding heavy ions at relativistic energies. Several probes and scientific methods are applied to characterize the QGP. Our research mainly focuses on

the study of hard probes and photon production using ALICE experiment at LHC. We also perform instrumentation, detector development and development of computing algorithms for detection and reconstruction of particles produced in these collisions.

Aims and Objectives

- Characterization of a new state of matter QGP: Performing experiments through the participation and contributions in the large international experimental collaborations such as ALICE at CERN, Geneva and CBM at FAIR, GSI, Germany to study and explore the QGP.
- Development of in-house facilities and expertise for detector R&D, instrumentation and computational techniques for big data analysis.
- Physics publications in journals about understanding of heavy ion collisions through formation and characterization of QGP.

Work Achieved

- Important contributions are made through active participation in the ALICE experiment at CERN, in terms of Physics analyses and maintenance and operations of the Photon Multiplicity Detector (PMD) in ALICE.
- Study of hard probes and photon production are being performed for pp and pPb collisions at 2.76 and 5.02 TeV respectively in ALICE.
- The dynamics of jet-medium interactions are being investigated using MC models (JEWEL, EPOS).
- Data quality control/monitoring and calibrations are performed for PMD in ALICE. We decommissioned the PMD from ALICE in December 2018.

Future Research Plans

- Physics analyses and publications of the LHC data to explore the Physics of strongly interacting matter at extreme energy density through characterization of QGP properties.
- Quality control, simulation, calibration, data production and analyses of the PMD data in the ALICE experiment..
- Production, tests and quality assessment of a Gas Electron Multiplier (GEM) based Muon Chamber (MUCH) detector for the CBM experiment at FAIR, GSI, Germany.
- R&D and building of a Forward Calorimeter for the ALICE upgrade at LHC to explore low-x Physics.
- R&D and commissioning of a cooling system for the MUCH detector in the CBM experiment.

Publications

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

- S. Acharya et al. (ALICE Collaboration) (2019) Centrality and pseudorapidity dependence of the charged-particle multiplicity density in Xe-Xe collisions at sqrt(sNN) = 5.44 TeV; Phys. Lett. B 790, 35-48.
- S. Acharya et al. (ALICE Collaboration) (2019) Multiplicity dependence of light-flavor hadron production in pp collisions at sqrt(s) = 7 TeV; Phys. Rev. C 99, 024906.
- S. Acharya et al. (ALICE Collaboration) (2019) Direct photon production at low transverse momentum in proton-proton collisions at sqrt(s) = 2.76 and 8 TeV; Phys. Rev. C 99, 024912.
- S. Acharya et al. (ALICE Collaboration) (2019) Charged jet cross section and fragmentation in proton-proton collisions at sqrt(s) = 7 TeV; Phys. Rev. D 99, 012016.
- S. Acharya et al. (ALICE Collaboration) (2019) Direct photon elliptic flow in Pb-Pb collisions at sqrt(sNN) = 2.76 TeV Phys. Lett. B 789, 308.
- S. Acharya et al. (ALICE Collaboration) (2019) Transverse momentum spectra and nuclear modification factors of charged particles in Xe-Xe collisions at sqrt(sNN) = 5.44 TeV; Phys. Lett. B 788, 166-179.
- S. Acharya et al. (ALICE Collaboration) (2018) Transverse momentum spectra and nuclear modification factors of charged particles in pp, p-Pb and Pb-Pb collisions at the LHC; JHEP 1811, 013.
- S. Acharya et al. (ALICE Collaboration) (2018) Medium modification of the shape of small-radius jets in central Pb-Pb collisions at sqrt(sNN) = 2.76TeV; JHEP 10, 139.
- S. Acharya et al. (ALICE Collaboration) (2018) Neutral pion and meson production at mid-rapidity in Pb-Pb collisions at sqrt(sNN) = 2.76 TeV; Phys. Rev. C 98, 044901.
- S. Acharya et al. (ALICE Collaboration) (2018) Anisotropic flow of identified particles in Pb-Pb collisions at sqrt(sNN) = 5.02 TeV; JHEP09 (2018) 006.
- S. Acharya et al. (ALICE Collaboration) (2018) Anisotropic flow in Xe-Xe collisions at sqrt(sNN) = 5.44 TeV; Phys. Lett. B 784, 82.
- S. Acharya et al. (ALICE Collaboration) (2018) Longitudinal asymmetry and its effect on pseudorapidity distributions in Pb-Pb collisions at sqrt(sNN) = 2.76 TeV; Phys. Lett. B 781, 20-32.
- S. Acharya et al. (ALICE Collaboration) (2018) Constraints on jet quenching in p-Pb collisions at sqrt(sNN) = 5.02 TeV measured by the event-activity dependence of semi-inclusive hadron-jet distributions; Phys. Lett. B 783, 95-113.

Invited Talk

Invited talk on "PMD results from SPS, RHIC and LHC" in a symposium on Heavy-ion physics at FAIR, RHIC and LHC facilities, held at NISER, Bhubaneswar (INDIA), during 18-19 June 2018.

Extramural Funding

I am involved in the following two International projects funded by DST, Govt. of India:

- **ALICE Project – II:** ALICE experiment at CERN, Geneva, Switzerland; PI: Dr. Supriya Das; Project Duration: 2014 – 2020; Allocated Fund: INR 14 Crores.
- **CBM MUCH project:** Muon Chamber Detector for the CBM experiment at FAIR; PI: Prof. Sanjay Ghosh; Project Duration: 2016-2021; Allocated Fund: INR 29 Crores.

Conferences(s) / Workshop(s)

Organized an "International Workshop on Forward and jet Physics at LHC" during 11 – 12 February, 2019 and "ALICE India Collaboration Meeting" during 13 – 16 February, 2019 at Bose Institute Kolkata.

DR. SOMSHUBHRO BANDYOPADHYAY
Professor

Name of the Participants

Group members: Prasenjit Deb, Arup Roy, Pratapaditya Bej, Abhishek Banerjee, Arkaprabha Ghosal.

Collaborators

Debarshi Das, Bose Institute; Saronath Halder, IISER Berhampur; Manik Banik, SN Bose center; Saptarshi Roy, HRI; Tomasz Paterek, NTU, Singapore.

Background

Information encoded in quantum systems is quantum information, and therefore, quantum information processing must obey the laws of quantum physics. The discovery of this simple idea has led to novel communication protocols including secure cryptography primitives, exceptionally fast algorithms and many applications in quantum many-body problems.

While quantum information and computation has been the cornerstone of cutting edge research in physics, mathematics, and computer science for many years now, especially because of the promise of revolutionizing the existing technology, our research, however, is mostly aimed at addressing fundamental

problems in the resource theory of entanglement, entanglement distribution, quantum state discrimination, quantum channels, quantum protocols and interpretation of quantum mechanics.

Aims and Objectives

The broad focus of our research group is to understand the role of quantum entanglement in distributed information processing tasks, and properties of quantum many-body systems within the paradigm of Local Operations and Classical Communication (LOCC). Specifically,

- Understanding the strengths and limitations of LOCC protocols—the protocols that play a fundamental role in distributed quantum information processing—in quantum state discrimination problems.
- Understanding quantum entanglement as a resource within the paradigm of LOCC but often enlarging the set of allowed quantum operations.
- Understanding quantum correlations in quantum many-body systems.

Work Achieved

- Demonstrated with explicit examples an extreme form of quantum non-locality without entanglement.
- Obtained an exact computable formula for fidelity deviation in quantum teleportation with an arbitrary two-qubit state.
- Characterized non-selective global projective measurements capable of increasing entanglement between two-particles.

Future Research Plans

- To obtain the exact entanglement cost and the corresponding optimal resource states in quantum state discrimination problems using LOCC.
- To understand the emergence of nonlocal properties in a two-body system, parts of which never interacted in the past, in the setting of entanglement swapping using weak measurements.
- To completely characterize quantum information processing tasks such as quantum teleportation, super-dense coding, quantum cloning, etc. in terms of fidelity and fidelity deviation.
- To develop a theory based on the techniques of quantum information to address the information paradox in black holes.

Students Awarded Ph.D.

Prasenjit Deb (CU, 2018) Role of Quantum Correlations in Quantum Information Processing.

Department of Physics

Invited Talks

- "Strong quantum nonlocality without entanglement" at QIPA 2018, HRI, Allahabad, December 2018.
- A series of four lectures on Quantum Information at the Department of Applied Mathematics, Calcutta University, March 2019.

Extramural Funding

SERB project (EMR/2015/002373) on "Studies on quantum entanglement as a resource in quantum information processing." June 2016-June 2019, Total cost: Rs. 17, 89, 344.00

Conferences/Workshops

QIPA 2018: Meeting on quantum information processing and applications, HRI, Allahabad, December 2-8, 2018.

Publications

1. Halder Saronath, Banik Manik, Agrawal Sristy , Bandyopadhyay Somshubhro (2019) , Strong quantum nonlocality without entanglement, *Phys. Rev. Lett.* 122, 040403.
2. Zuppardo Margherita, Ray Ganardi, Miller Marek, Bandyopadhyay Somshubhro, Paterek Tomasz (2019) Entanglement gain in measurements with unknown results, *Phys. Rev.* A 99, 042319.

DR. SOUMEN ROY

Associate Professor

Name of the Participants

Deep Nath, JRF, Saptarshi Sinha, SRF

Background

Diverse natural, engineered and economic systems are composed of many constituents and subconstituents interacting non-trivially amongst themselves and perhaps even with the environment. Examples of such natural systems can be found in the physical as well as the biological world. Networks often beautifully capture the architecture of the underlying complexity in these systems. Non-linear dynamics and game theory are some other useful tools to study such systems. We employ a fully interdisciplinary approach using tools from physics, mathematics, statistics, network science, computation and experiments. Almost all of our published work is based on empirical or experimental data.

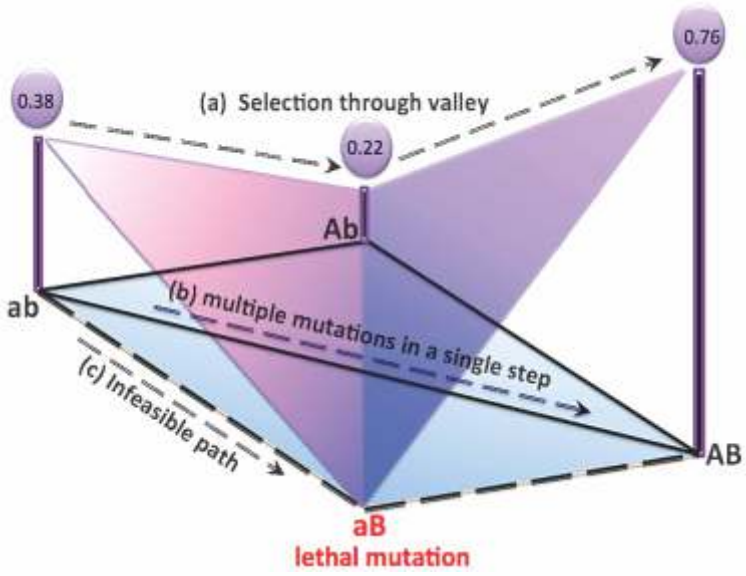
Department of Physics

Aims and Objectives

Strictly adaptive evolutionary walks on uncorrelated and correlated fitness landscapes have been the subject of intense research for nearly a century now. However, more recent experimental findings tend to advance the notion of non-adaptive evolution in terms of epistasis. We want to mathematically address such evolutionary paths, obviously in total agreement with experimental results.

Work Achieved

We introduce the concept of topologically inspired walks on connected and correlated landscapes with complex topologies. These walks are dictated solely by the topology of connections and are not explicitly dependent on the underlying fitness values. In the biologically significant regime of sparse randomness, we observe that such topologically inspired walks might carry a population to a local optimum even faster than strictly adaptive walks. This effect becomes more pronounced with increasing correlations in fitness. We observe interesting tradeoffs between topologically inspired walks governed by the minimum and maximum value of a set of given network metrics.



Experimentally observed yet lesser studied paths for a 2-string genotype are shown in this representation of a realistic fitness landscape. All possible mutations for a 2-string genotype can be represented as "ab","AB","Ab" and "aB". Here "aB" is presumed as lethal. Fitness value of each genotype resulting from epistatic interaction is also mentioned. Apart from well-known adaptive walks, three other possible evolutionary paths are: (a) Non-adaptive path passing through a valley "ab" "Ab" "AB", (b) multiple mutations in a single step, and, (c) infeasible path leading to the lethal mutation "aB". Topologically inspired walks on fitness landscapes with heterogeneous connectivities can successfully model (a), (b), and (c).

Future Research Plans

(a) Role of topology on the outcome of games on networks

(b) Studies on mutagenesis using experiments and rigorous mathematical results

Publications

1. Grewal RK, Sinha S, and Roy S (2018) Topologically inspired walks on randomly connected landscapes with correlated fitness. *Frontiers in Physics*, 6, 138.

2. Sinha S, Ghosh S and Roy S (2019) A pedestrian review of games on structured populations. *International Journal of Advances in Engineering Sciences and Applied Mathematics,* 11, 138-152.

3. Sinha S, Grewal RK, and Roy S (2018) Modeling bacteria-phage interactions and implications for phage therapy. *Advances in Applied Microbiology*, 103, 103-141.

Invited Talks

International Centre for Theoretical Physics (UNESCO), Trieste, Italy, November 29, 2018

International Conference on Complex Dynamical Networks, Physics and Applied Mathematics Unit, Indian Statistical Institute, Kolkata, October 4-5, 2018

Workshop on Mathematical and Computational Biology, Indo-French Centre for Applied Mathematics, Indian Institute of Science, Bangalore, July 16-30, 2018

Annual Conference of Ramanujan Mathematical Society, Department of Mathematics, University of Delhi, June 1-3, 2018

Extramural Funding

Identification and validation of structural hot spots in signaling network of few blue-light responsive photoreceptors using complex networks and biophysical techniques 2016-2019 (SERB, DST, India)

Characterization of few blue light sensing photoreceptors with transcription factor activity: A molecular approach 2019-2022 (DBT, India)

Awards / Honours / Memberships

Regular Associate, International Centre for Theoretical Physics (UNESCO), Trieste, Italy

Academic Editor, PLOS ONE

Conference(s) / Workshop(s) : Number of abstracts – 2

DR. SUPRIYA DAS
Associate Professor

Name of the Participants

Rathijit Biswas, Md. Asif Bhat, Susnata Seth, Sanjoy Mukherjee

Background

Study of matter at extreme condition:

For a long time now scientists all over the world are trying to know about the state of the matter that existed just after the big bang that is believed to have created this universe. The only way to study and characterize this state of the matter is to create it in the laboratory. To achieve this goal a number of high energy accelerators are engaged to collide heavy ions moving in relativistic speed. In these collision a temperature similar to that existed during the time of the big bang is obtained. Theoretical understanding tells us that at this temperature the hadrons melt liberating the quarks and gluons, which forms a soup of deconfined state of matter. However, the temperature soon decreases and the quarks and gluons get confined again to form normal nuclear matter. But the particles formed carry certain signatures, which reveal the features of the matter from which they are generated.

Another extreme condition exists inside the core of neutron stars where the density is very high ($\sim 10^{14}$

times the density of the Sun). It is again believed that the matter at such densities is a soup of deconfined quark and gluons rather than normal nuclear matter. Facilities are being built to create the matter at such high densities inside laboratory to characterize that.

Cosmic rays are high-energy charged particles (~90% of them are protons) that enter into our atmosphere from different sources. They can be detected in direct method by putting detectors in balloons or satellites. But these particles produce hadronic /electromagnetic showers while travelling through the atmosphere and employing ground-based detectors are another way of detecting them.

Aims and Objectives

i) Characterize matter at extreme high temperature using hard probes such as 'jets'.

ii) Development of new particle detectors to study matter at extreme temperature and Densities.

iii) Detect and study properties of cosmic ray air shower at mountain altitude.

Work Achieved

i) Particle production mechanism in intermediate transverse momentum range for small collision system at relativistic energies has been probed using identified triggered correlation. This work was carried out using PYTHIA and EPOS models in case of pp collisions at \sqrt{s} = 7 TeV. The study shows that pion and proton triggered correlations in case of hydrodynamic evolution compared to multi-particle interaction with color reconnection yield very different results and therefore could be used to disentangle the effect of one from the other in case of experimental data.

ii) The performance of a stack of 4-GEM detector had been tested using 1 GeV pion beam. A 10 % variation of local gain obtained from this study is well within the limit for tracking requirements. The dE/dx resolution and hence the PID performance is compatible with the requirements for the ALICE TPC upgrade program.

iii) A cosmic ray air shower detector array using 7 large (1m x 1m) plastic scintillator detectors has been developed and commissioned at the Darjeeling campus of Bose Institute. This array is being used to detect and count the cosmic ray air showers at an altitude of ~2200m a.s.l.

Future Research Plans

i) Study of jet-medium interaction using jet-shape observables such as fragmentation function and radial momentum distribution within the jets.

ii) Study of photon production at forward rapidities using ALICE data

iii) Develop and fabricate the GEM-based muon detection system for the forthcoming CBM experiment at FAIR.

iv) Development of an electromagnetic calorimeter to study the physics at forward rapidities at relativistic heavy ion collisions.

Publication(s)

1. Particle identification studies with a full-size 4-GEM prototype for the ALICE TPC upgrade, *Nucl. Inst. Meth.* A903, 215 (2018), doi : https://doi.org/10.1016/j.nima.2018.06.084.
2. Longitudinal asymmetry and its effect on pseudorapidity distributions in Pb-Pb collisions at \sqrt{s_NN} = 2.76 TeV, *Phys. Lett. B* 781 (2018) 20-32 .
3. First measurement of $^{0}_{c}$ production in pp collisions at \sqrt{s} = 7 TeV, *Phys. Lett. B* 781 (2018) 8-19.
4. $^{+}_{c}$ production in pp collisions at \sqrt{s} = 7 TeV and in p-Pb collisions at \sqrt{s_NN} = 5.02 TeV, *JHEP* 04 (2018) 108.
5. Prompt and non-prompt J/ production and nuclear modification at mid-rapidity in p-Pb collisions at \sqrt{s_NN} = 5.02 TeV - *Eur. Phys. J.* C 78 (2018) 466.
6. Constraints on jet quenching in p-Pb collisions at \sqrt{s_NN} = 5.02 TeV measured by the event-activity dependence of semi-inclusive hadron-jet distributions - *Phys. Lett. B* 783 (2018) 95-113.
7. Measurement of the inclusive J/ polarization at forward rapidity in pp collisions at \sqrt{s} = 8 TeV - *Eur. Phys. J. C* 78 (2018) 562.
8. meson production at forward rapidity in Pb-Pb collisions at \sqrt{ s_NN} = 2.76 TeV - *Eur. Phys. J. C* 78 (2018) 559.
9. Energy dependence and fluctuations of anisotropic flow in Pb-Pb collisions at \sqrt{s_NN} = 5.02 and 2.76 TeV - *JHEP* 07 (2018) 103.
10. Inclusive J/ production at forward and backward rapidity in p-Pb collisions at \sqrt{s_NN} = 8.16 TeV - *JHEP* 07 (2018) 160.
11. Anisotropic flow in Xe-Xe collisions at \sqrt{s_NN} = 5.44 TeV - *Phys. Lett.* B784 (2018) 82.
12. Neutral pion and meson production in p-Pb collisions at \sqrt{s_NN} = 5.02 TeV - *Eur. Phys .J.* C78 (2018) 624.
13. Inclusive J/ production in Xe-Xe collisions at \sqrt{s_NN} = 5.44 TeV - *Phys. Lett. B* 785 (2018) 419-428.
14. Anisotropic flow of identified particles in Pb-Pb collisions at \sqrt{s_NN} = 5.02 TeV - *JHEP09* (2018) 006 .
15. Azimuthally-differential pion femtoscopy relative to the third harmonic event plane in Pb-Pb collisions at \sqrt{s_NN} = 2.76 TeV - *Phys. Lett. B* 785 (2018) 320.
16. Dielectron production in proton-proton collisions at \sqrt{ } = 7 TeV - *JHEP* 1809 (2018) 064.
17. Neutral pion and meson production at mid-rapidity in Pb-Pb collisions at \sqrt{s_NN} = 2.76 TeV - *Phys. Rev.* C 98, 044901 (2018).
18. Medium modification of the shape of small-radius jets in central Pb-Pb collisions at \sqrt{s_NN} = 2.76TeV - *JHEP* 10 (2018) 139.
19. Transverse momentum spectra and nuclear modification factors of charged particles in pp, p-Pb and Pb-Pb collisions at the LHC - *JHEP* 1811 (2018) 013.

20. Transverse momentum spectra and nuclear modification factors of charged particles in Xe-Xe collisions at \sqrt{s_NN} = 5.44 TeV - *Phys. Lett. B* 788 (2019) 166-179.
21. Measuring $K^0_sK^{\pm}$ interactions using pp collisions at \sqrt{s} = 7 TeV - *Phys. Lett.* B 790 (2019) 22.
22. Y suppression at forward rapidity in Pb-Pb collisions at sNN = 5.02 TeV - *Phys. Lett.* B 790 (2019) 89.
23. Direct photon elliptic flow in Pb-Pb collisions at \sqrt{s_NN} = 2.76 TeV - *Phys. Lett.* B 789 (2019) 308.
24. Charged jet cross section and fragmentation in proton-proton collisions at \sqrt{s} = 7 TeV - *JHEP* 1902 (2019) 012.
25. Direct photon production at low transverse momentum in proton-proton collisions at \sqrt{s} = 2.76 and 8 TeV - *Phys. Rev.* C 99, 024912 (2019).
26. Dielectron and heavy-quark production in inelastic and high-multiplicity proton-proton collisions at \sqrt{s} = 13 TeV - *Phys. Lett.* B 788 (2019) 505.
27. Suppression of (1520) resonance production in central Pb-Pb collisions at \sqrt{s_NN} = 2.76 TeV - *Phys. Rev.* C 99, 024905 (2019).
28. Multiplicity dependence of light-flavor hadron production in pp collisions at \sqrt{s} = 7 TeV - Phys. Rev. C 99, 024906 (2019).
29. p-p, p- and - correlations studied via femtoscopy in pp reactions at \sqrt{ } = 7 TeV - *Phys. Rev.* C 99, 024001 (2019).
30. Measurement of dielectron production in central Pb-Pb collisions at \sqrt{s_NN} = 2.76 TeV - *Phys. Rev.* C 99, 024002 (2019).
31. Azimuthal anisotropy of heavy-flavour decay electrons in p-Pb collisions at \sqrt{s_NN} = 5.02 TeV - *Phys. Rev. Lett.* 122, 072301 (2019).
32. Centrality and pseudorapidity dependence of the charged-particle multiplicity density in Xe-Xe collisions at \sqrt{s_NN} = 5.44 TeV - *Phys. Lett.* B 790 (2019) 35-48.

Extramural Funding

i) A Large Ion Collider Experiment (ALICE) – Operation, Utilization and Maintenance, DAE & DST collaborative project: SR/MF/PS-01/2014-BI dt. 15.09.2014 – 13,84,50,000/- (for 5 years) [PI since 2017].

ii) CBM Muon Chamber: BI-IFCC/2016/1082(A) dt. 14.06.2016 – Rs. 28,80,40,000/- (for 06 years).

Conference(s) / Workshop(s)

i) ALICE-India Collaboration meeting during 13.02.19 – 16.02.19 (organizer).

ii) International Workshop on Forward and Jet Physics at LHC (organizer).

DR. TRIPURARI PRASAD SINHA
Professor

Photo physical and transport properties of perovskite oxides

Name of the Participants

JRF: Tushar Kanti Bhowmik, Ranjan Sutradhar, Sumana Gop, Himadri Sekhar Tripathi

SRF: Saswata Halder, Md. Sariful Sheikh, Ram Awdhesh Kumar, Moumin Rudra

RA: Alo Dutta

Collaborators

Dr. Sayan Bhattacharya, Department of Chemical Sciences, IISER Kolkata; Dr. Sourish Banerjee, Department of Physics, University of Calcutta; Dr. Sachindra Nath Das, Department of Instrumental Science, Jadavpur University; Dr. Amitava Bhattacharyya, Department of Physics, RKMVERI Belur.

Background

With the rapid development of the electronic information technology, the requirement for dielectric ceramics with high dielectric permittivity and low dielectric loss is becoming more and more urgent. In

this respect, the complex perovskite oxides ($AB_xB_yO_3$, A = monovalent, divalent, trivalent metals and B = transition metals) provide a wide range of suitable materials due to the possibilities of tailoring the chemistry and consequently the parameters to meet the device requirements. We have been associated with the design and synthesis of advanced materials particularly perovskite oxides, and their characterization by various experimental techniques to investigate its nobel electronic properties. Understanding these properties compliments the drive for their technological applications.

Aims and Objectives

- To identify the photo-catalytic degradation of the organic pollutant under the visible light irradiation using the perovskite oxides.
- To understand the light induced charge transport in the double perovskite oxides based Schottky diode.
- To detect the photosensitive nature of the double perovskite oxides under a simulated sunlight.
- To determine the microwave dielectric properties of the perovskite oxides.
- To perceive the dielectric relaxation of perovskite oxides

Work Achieved

Photocatalytic performance of rare-earth orthoferrite perovskite oxides

The use of the perovskite oxides as the photocatalyst for the degradation of the aquatic pollutants and for the renewable energy is of huge research interest. The photocatalytic activity of Mn doped SmFeO3 perovskite oxides synthesized by the sol–gel route has been investigated. The materials are characterized by the scanning electron microscopy, UV–Visible diffuse reflectance spectroscopy, photoluminescence spectroscopy and impedance spectroscopy. The photocatalytic activity of the materials is achieved by the photocatalytic decomposition of the aqueous solution of the pollutant rhodamine B (Rh-B) under the visible light irradiation. The photocatalytic efficiency enhances with Mn doping. The 50% Mn doped SmFeO3 (SmFe0.5Mn0.5O3) shows 57 % degradation of Rh-B in 4 h. The highest photocatalytic activity of SmFe0.5Mn0.5O3 is related to the smallest radius of the impedance arc which happens due to more separation and migration of the electron hole pairs The enhanced photocatalytic activity in these materials may be due to the increased optical absorption, the decreased recombination probability of the electron–hole pairs, as well as the efficient migration of the photogenerated charge carriers. The mechanism of the photocatalytic activity of the materials has also been discussed.

Perovskite oxide as promising solar cell absorber

The double perovskite oxide Sm2NiMnO6 (SNMO) has been considered as a promising solar cell absorber due to its large absorption coefficient in the visible region, large carrier life time and the high photo current density. Nano-particles of SNMO are synthesized by the sol-gel method. The synthesized SNMO nano-particles are characterized by the X-ray diffraction, transmission electron microscopy and UV–visible absorption spectroscopy. The measured direct optical band gap of 1.41 eV is found to be very close to the Shockley-Quiesser band gap value of a single junction solar cell. DFT calculations show that SNMO has a large value of absorption coefficient in the visible region, which is comparable to that of some standard photovoltaic materials such as Si, CH3NH3PbI3, etc. In addition, the photocatalytic degradation of Rhodamine B under the visible light and photocurrent density measurements under a simulated sunlight (AM1.5G) are performed to elucidate the photosensitive nature of SNMO.

Electrical properties of double perovskite oxide

The crossover between two different conduction mechanisms (variable range and small polaron hoppings) is probed utilizing a conjunction of thermally varying conductivity and impedance in polycrystalline Pr2NiTiO6 (PNT). A combination of X-ray diffraction (XRD) and Raman spectroscopic investigations authenticates the lower symmetric monoclinic structure for PNT. The conductivity, impedance and relaxation spectra highlight the combined contributions of the electrodes, grain-boundaries and grain microstructures to the carrier dynamics in PNT. The relaxation mechanism has a non-ideal nature with distribution of relaxation times as observed from the dielectric and impedance spectroscopic data. The dc resistivity investigation points towards a transition in the conduction mechanism showing a gradual crossover at temperature 490 K, from small polaron hopping to Mott's variable range hopping due to reduced activation energy.

Publications

1. Mukherjee R, Dutta A and Sinha T P (2018) Octahedral distortion-driven electrical and vibrational properties of A2ErTaO6 (A = Sr and Ca) double perovskite oxides, *Journal of Advanced Dielectrics,* vol. 8, pp. 1850025-1-8.

2. Sheikh Md S, Chanda S, Dutta A, Das S and Sinha T P (2018) Schottky diode like behaviour in Ag/Dy2NiMnO6/FTO device, *Materials Today: Proceedings* vol. 5, pp. 9839–9845.

3. Saha S, Maity R, Sakhya A P, Chanda S, Dutta A and Sinha T P (2018) Ac Conductivity And Raman Spectroscopic Studies Of PrMnO3 Nanostructure, *Materials Today: Proceedings* vol. 5, pp. 9981–9988.

4. Maitya R, Sakhya A P, Dutta A and Sinha T P (2019) Investigation of concentration dependent electrical and photocatalytic properties of Mn doped SmFeO3, *Materials Chemistry and Physics*, vol. 223, pp. 78–87.

5. Maity R, Sakhya A P, Dutta A and Sinha T P (2019) Effect of Sm doping on the structural, morphological and dielectric properties of EuFeO3 ceramics, *Solid State Sciences*, vol. 91, pp. 28–35.

6. Sheikh Md S, Sakhya A P, Maity R, Dutta A and Sinha T P (2019) Narrow band gap and optical anisotropy in double perovskite oxide Sm2NiMnO6: A new promising solar cell absorber, *Solar Energy Materials and Solar Cells* vol. 193, pp. 206–213.

7. Rudra M, Halder S, Saha S, Dutta A and Sinha T P (2019) Temperature dependent conductivity mechanisms observed in Pr2NiTiO6, *Materials Chemistry and Physics*, vol. 230, pp. 277–286.

Conferences/Workshops

No. of Abstracts: India: 6; International : 3 (Belgium: 1, UK: 1 and USA: 1)

Division of Plant Biology

Introduction

Innovation in plant science to ensure food security and food safety is the long-time goal of this division. In the backdrop of global warming, shrinking land area and the increasing threat of abiotic and biotic stresses, increase in crop production by minimization of yield loss and efficient utilization of natural resources are primary needs of the time. Therefore, the development of 'smarter' plants resilient to the ever-changing harsh climatic conditions and enhancement of plant genetic resource base are the unified mission of all plant scientists in the Division of Plant Biology. The primary activities include enhancement of both fundamental knowledge-base and technological advancements in the area of plant stress biology, plant developmental biology and microbial biology. The technological mission consists of an amalgamation of a plethora of information emanating from the identification of rare alleles through genomics-assisted molecular breeding, transcriptomics, proteomics, networking of the response regulating genes, bioinformatics, and genome engineering tools.





Division of Plant Biology

Faculty

Dr. Debabrata Basu, Professor and Head; Dr. Shubho Chaudhuri, Professor; Dr. Gaurab Gangopadhyay, Professor; Dr. Pallob Kundu, Associate Professor; Dr. Anupama Ghosh, Assistant Professor.

Research Scientist

Prof. A. N. Lahiri Majunder, INSA Senior Scientist; Prof. Sampa Das, INSA Senior Scientist; Prof. Amita Paul; Prof. Swati Gupta Bhattacharya; Prof. Samir Ranjan Sikdar.

Staff Members

Dr. Chaitali Roy, Technical Officer; Mr. Subal Basak, Assistant Registrar; Mr. Ashim Kumar Nath, Technical Officer-I; Mr. Jadab Kumar Ghosh, Technical Officer-I; Ms. Kaberi Ghosh, Technical Officer-I; Mr. Binoy Krishna Modak, Technical Officer-I; Mr. Jayasish Ghosh, Senior Laboratory Assistant; Mr. Bipul Kumar Nag, UDC-I; Mr. Sanjib Kumar Das, Lower Division Clerk; Mr. Arup Kumar Dey, Helper-E; Mr. Nadiram Kayal, Helper-E; Mr. Birendra Kumar Bari, Helper-E; Mr. Chanchal Chakraborty, Technical Officer-I (Superannuated on 31.01.2019); Mr. Siddhartha Roy, Helper-D; Ms. Moumita Mondal, Helper-C; Mr. Tapas Chakraborty, Helper-C.

Students/RA/Project Assistant

Dr. Swagata Ghosh, RA; Dr. Sathi Paul, RA; Dr. Alka Kumari, RA; Dr. Sambit Datta, RA; Dr. Arpita Basu Chowdhuri RA, (NPDF); Dr. Jayanti Jodder, RA; Dr. Anindya Kundu, RA; Dr. Mrinmoy Majumder, RA; Dr. Supriyo Chowdhury, RA, (DBT-RA); Dr. Gourav Sircar, RA; Mr. Rahul Dutta, SRF; Mr. Dibya Mukherjee, SRF; Ms. Udita Acharya, SRF; Ms. Aishee De, SRF; Ms. Surbhi Shriti, SRF; Mr. Subhasish Mukherjee, SRF; Ms. Shreya Chowdhury, SRF; Mr. Rohit Das, SRF; Ms. Jinia Chakrabarty, SRF; Ms. Shrabani Basak, SRF; Ms. Pratiti Dasgupta, SRF; Ms. Sanghamitra Adak, SRF; Mr. Sayantan Ghosh, SRF; Ms. Amrita Mukherjee Ganguli, SRF; Ms. Banani Mandal, SRF; Ms. Rwitie Mallik, SRF; Ms. Srimoyee Banarjee, SRF; Mr. Amit Paul, SRF; Mr. Debabrata Dutta, SRF; Ms. Bijaya Karmakar, SRF; Ms. Sangita Roy, SRF; Ms. Moumita Bhowmik, SRF; Ms. Moumita Biswas Sarkar, SRF; Ms. Koyel Sengupta, SRF; Mr. Sourav Bose SRF; Ms. Anisha Roy, JRF; Mr. Aroni Mitra, JRF; Ms. Ruby Biswas, JRF; Ms. Trisha Bhattacharyya, JRF; Ms. Sonal Sachdev, JRF; Mr. Sayan Mal, JRF; Mr. Himadri Das, JRF; Ms. Ananya Mukherjee, JRF; Mr. Vivek Awon, JRF; Ms. Diptasree Kumar, JRF; Ms. Soumili Pal, JRF; Ms. Trisha Bhattacharya, JRF; Mr. Shubham Bhakta, JRF; Mr. Sukhendu Maity, JRF; Mr.Pankaj Kumar Sing, Research Assistant; Ms. Anamika Pal, Research Assistant; Mr. Abhishek Mukherjee, Research Assistant; Mr. Soumya Subhra Gupta, Research Assistant; Ms. Rajat Kanti Sarkar, Research Assistant; Ms. Tanusri Gayen, Research Assistant; Sayani De.

DR. ANUPAMA GHOSH
Assistant Professor

Name of the Participants

Rahul Datta, SRF, Institute Fellow; Dibya Mukherjee, SRF, Institute Fellow; Udita Acharya, SRF, Institute fellow; Subhasish Mukherjee, SRF, UGC *Adhoc*; Aroni Mitra, DBT-JRF; Anisha Roy, DBT-JRF; Alka Kumari, CSIR-RA.

Background

We work on various aspects of plant microbe interactions. In particular the primary focus of our research involves exploring the molecular cross talks between a fungal phytopthogen *Ustilago maydis* and its host *Zea mays* that leads to establishment of biotrophic interaction between them. The primary focus of the lab is to understand the molecular strategies of disease establishment by fungal phytopathogens involving a huge array of secreted effector proteins most of which are orphan proteins with no known functions.

Aims and Objectives

- Deciphering the biological functions of secreted effector proteins of *Ustilago maydis*.
- Understanding the apoplastic defence response of host plants against pathogen infection.
- Identifying the effectors of extracellular defence in host plants.

Work Achieved

- Virulence functions for extracellular ribonucleases of *Ustilago maydis* have been established.
- Extracellular defence response of rice towards infection with *Rhizoctonia solani* AG1IA is revealed through apoplastic proteome study.

Future Research Plans

- Investigating the host targets for different classes of *Ustilago maydis* effector proteins.
- Investigating the molecular cross talks between model rhizobacterium and maize plants using transcriptome analysis.
- Identifying the components of extracellular defence response of host plants against pathogen invasion.

Publication

Mukherjee D, Mitra A, Ghosh A (2018) Detection of apoptosis like cell death in *Ustilago maydis* by annexin V-FITC staining; *Bioprotocol* 2018, Vol 8, Issue 15.

Extramural Fundings

Evaluation of secreted proteases of *Ustilago maydis* as potential effector proteins; SERB (Early Career Research Award).

Survival strategies of corn smut fungus Ustilagomaydis during host colonization; DST (INSPIRE-Faculty Award), Termination date: 09th October 2018.

Awards/Honours/Memberships

Dibya Mukherjee received SERB International Travel Support for delivering a talk and presenting a poster entitled “Virulence functions for two T2 type extracellular ribonucleases of *Ustilago maydis*" in the 30th Fungal genetics conference held at Asilomar conference grounds Pacific Grove , CA during 12th to 17th March 2019

Conference/Workshop

Dibya Mukherjee delivered a talk and presented a poster entitled "Virulence functions for two T2 type extracellular ribonucleases of *Ustilago maydis*" in the 30th Fungal genetics conference held at Asilomar conference grounds Pacific Grove , CA during 12th to 17th March 2019

DR. DEBABRATA BASU
Professor

Name of the Participants

Dr. Swagata Ghosh, Dr. Mrinmoy Majumder, Ms. Aishee De, Ms. Banani Mandal, Ms. Amrita Mukherjee, Mr. Tapas Chakraborty, Uttam Das.

Background

Non-host resistance (NHR) is more durable and sometimes capable of conferring resistance against entire races of a particular pathogen. Furthermore, in NHR effective accomplishment of both PAMP-triggered Immunity (PTI) and Effector-Triggered Immunity (ETI) result in a more broad-spectrum resistance. This hinders co-evolution of new resistant strains compared to what happened in R gene and Avr gene mediated gene-for-gene resistance on prolonged interaction between resistant/tolerant plants with a pathogen. With this view, identification of molecular factors associated with non-host resistance of *Sinapis alba* against oilseed mustard 'Black Spot' disease-causing necrotrophic fungal pathogen *Alternaria brassicicola* has been pursued. 'Black Spot' disease is a significant threat to oilseed mustard-like *Brassica juncea*, *Brassica rapa* and *Brassica napus* since the germplasms of these important crops lack the source of resistance against this damaging and widespread pathogen. However, *Sinapis alba* (white mustard) and *Arabidopsis* are known to exhibit non-host resistance against this pathogen. *Sinapis alba* and *Arabidopsis thaliana* both belong to the same

Brassicaceae family as oilseed mustard. In this respect, we have focused our research on exploring the integrated plant defence responses in the different levels of plant signalling.

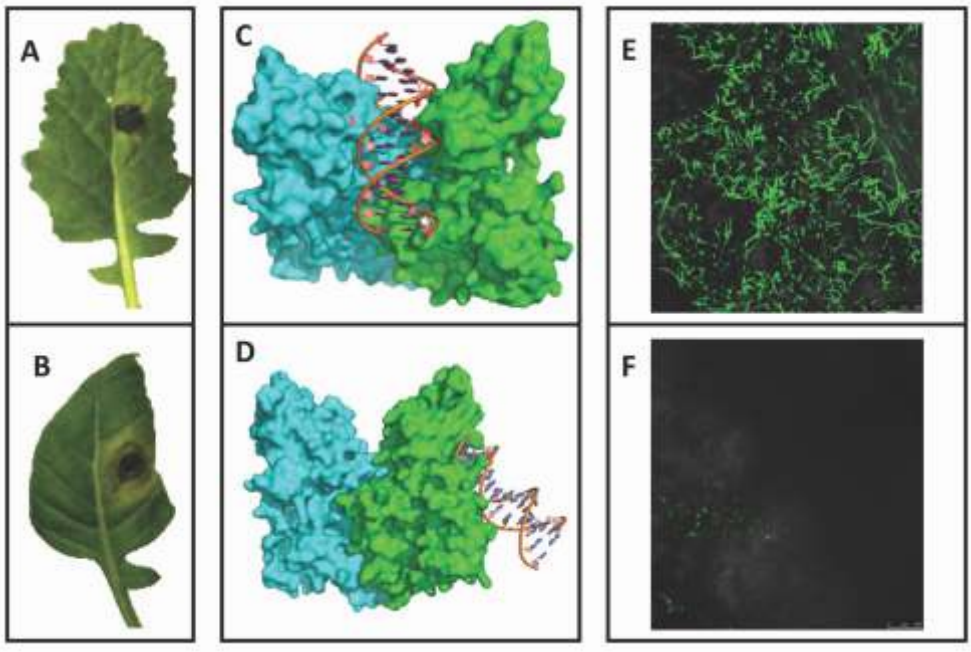
Aims and Objectives

Understanding and functional analysis of molecular factors responsible for resistance response against oilseed mustard 'Black Spot' disease-causing fungal pathogen *Alternaria brassicicola*.

Work Achieved

Establishment of *Alternaria brassicicola* tolerant *Brassica juncea* lines through conditional expression of ARF10. *In collaboration with Subhrangsu Chatterjee and Nrisingha Dey*

ARF10, a major player in ABA-auxin crosstalk, was cloned under a pathogen inducible promoter GH3.3 from *B.juncea*. Transgenic *B.juncea* plants conditionally expressing ARF10 exhibited elevated expression of ABA-responsive genes like *ABI3*, *ABI4* and *ABI5* while the expressions of auxin biosynthetic genes were not changed upon pathogen challenge. Induced ABA sensitivity caused by conditional expression of ARF10 in transgenic *B. juncea* resulted in tolerance against *A. brassicicola* along with phenotypic changes like stunted growth, reduced seed size, altered root length, and late seed germination. Through *in vitro* DNA-protein experiments and chromosome immunoprecipitation using the ARF10 antibody, we demonstrated that ARF10 interacts with upstream auxin-responsive elements of *ABI5* promoter. This suggests that ARF10 may function as a modulator of ABI5 to induce ABA sensitivity and mediate the resistance response against *A. brassicicola*.



A. brassicicola infected A. ARF10 transgenic *B. juncea* leaves, B. Untransformed *B. juncea* leaves. Docking with ARF10 protein with C. ABI5 promoter & ABI3 promoter. Callose deposition in the leaves of *B. juncea* on the challenge with *A. brassicicola* E. ARF 10 transgenic F. untransformed

Assessment of quantitative basal resistance against *Alternaria brassicicola* among the susceptible *B. juncea* varieties

Alleles of ABA biosynthesis / responsive genes NCED3, ABI5 and ARF10 were selected in *A. brassisicola* tolerant lines B4 and B19, based on their up-regulation as compared to susceptible genotype, B85. Promoter regions of NCED3, ABI5 and ARF10 genes were cloned, sequenced and compared with the susceptible one for the identification of SNPs. Validation of functional SNP markers in the F4 population of a parental combination of tolerant EC299312 and susceptible B85.

Future Research Plans

- Functional assessment of the ARF10, NAC 62 and LYK4 transgenic *B. juncea* plants and identification of downstream genes associated with resistance against *A. brassicicola*.
- Molecular characterization of effectors of *Alternaria brassicicola* and identification of interactors from resistant *Sinapis alba*.
- Validation of functional markers and characterization of *A. brassicicola* tolerant F5 breeding lines.

Publication

1. Mukherjee A, Mazumder M, Jana J, Srivasatava A Kumari, Mondal B, De A, Ghosh S, Saha U, Bose R, Chatterjee S, Dey N and Basu D (2019) Enhancement of ABA sensitivity through conditional expression of ARF10 gene in *Brassica juncea* exhibit fertile plants with tolerance against *Alternaria brassicicola*; International Society for Molecular Plant Microbe Interaction.

DR. GAURAB GANGOPADHYAY
Professor

Name of the Participants

Mr. Debabrata Dutta, UGC – SRF; Ms. Soumili Pal, INSPIRE – JRF; Mr. Vivek Awon, UGC – JRF; Ms. Diptasree Kumar, WBDBT project – JRF.

Collaborators

Ms. Sananda Bhattacharya, PhD student Collaborator Dr. S K Datta, Department of Botany, CU; Ms. Shinjini Sengupta, PhD student, Department of Botany, CU - Collaborator Dr. S K Datta, Department of Botany, CU; Dr. Andrea Harper, University of York, UK - Mentor of Mr. Debabrata Dutta (for the Newton-Bhabha PhD placement award 2018-19).

Background

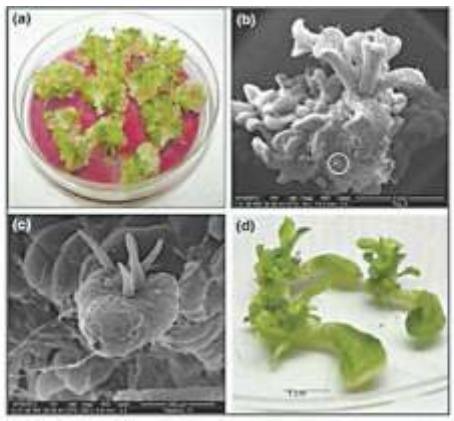
A plant scientist, having a 'feel' for the minute details of the plants - and a belief that understanding the molecular basis of subtle variations can enhance a plant's performance in the field against biotic and abiotic stress.

Aims and Objectives

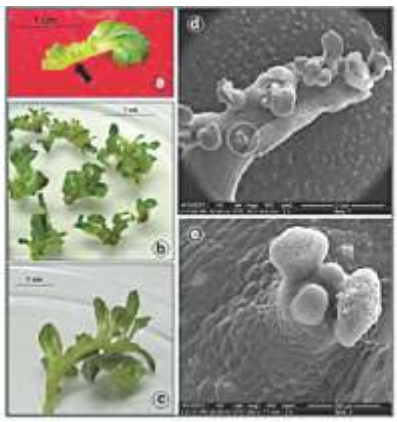
Exploration of the wild gene pool to enhance the quality and quantitative produce of the crop plants.

Work Achieved

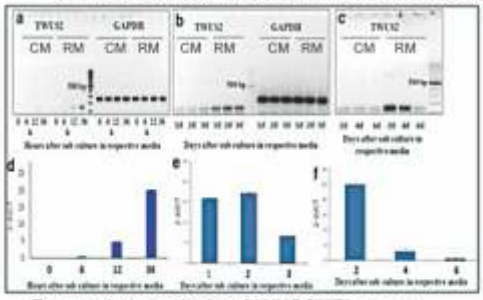
- We have established the early expression of WUSCHEL as a marker for *in vitro* shoot morphogenesis in tobacco and *Beta*:



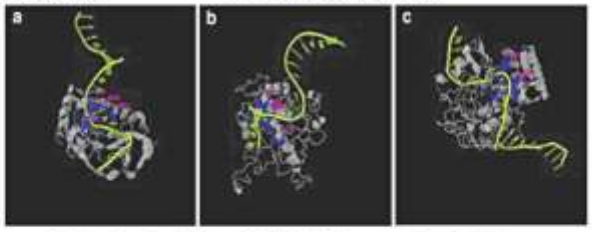
Somatic embryogenesis and organogenesis of tobacco



Organogenesis of *Beta*



Expression analysis of WUSCHEL gene



Molecular docking of WUSCHEL protein of (a) *Beta palonge*, (b) *Beta vulgaris* and (c) *Arabidopsis*

Early expression of WUSCHEL is a marker for *in vitro* shoot morphogenesis in tobacco and *Beta palonga* : Figures from publication–Sultana, M and Gangopadhyay, G(2018) Plant Cell Tissue and Organ Culture **134: 277 – 288 (online version https://doi.org/10.1007/s11240-018-1421=x)**

- We have characterized few F_6 recombinant lines of inter-specific hybrids of sesame for oil quality:

  The presence of lignans (sesamin, sesamol) adds pharmaceutical value in oil of cultivated sesame. Wild sesame, *Sesamum mulayanum*, though less oil-yielding but contains remarkably higher lignan in oil. We performed an inter-specific hybridization between cultivated Indian sesame (*S. indicum*) and *S. mulayanum* to bring a better oil profile in the cultivated sesame. For molecular marker-assisted selection, we have validated six seed-specific candidate genes in different developmental stages in the parents. Of the genes, sesamin synthase, having a direct relation with sesamin content, and fatty acid desaturase, regulating PUFA content in oil were the most potential candidate genes. With a 'heat-map' approach we selected the most desirable genotype in the F_6 recombinant lines. This line showed high oil content with a superior lignan profile and manifested distinct traits of seed coat colour for phenotypic selection (The work is yet to be published).

Future Research Plans

- Development of transgenic pineapple over-expressing *AcSERK* to combat fungal pathogens.
- Identification of beneficial rhizospheric fungi to booster the growth of Darjeeling tea.

Students Awarded PhD

- Vivek Arora (CU, 2018) Analysis of genetic diversity and molecular marker assisted screening of a hybrid population of Mulberry (Morus spp.; Family: Moraceae) to look for useful recombinants.
- Marufa Sultana (CU, 2018) Study on molecular factors associated with *in vitro* plant morphogenesis.

Publications

1. Sultana M and Gangopadhyay G (2018) Early expression of WUSCHEL is a marker for *in vitro* shoot morphogenesis in tobacco and *Beta palonga*. Plant Cell Tissue and Organ Culture 134: 277 – 288 (online version https://doi.org/10.1007/s11240-018-1421-x) Impact Factor 2.200.
2. Bose S, Gangopadhyay G and Sikdar SR (2018) RiHSPRO2, a nematode resistance protein-like homolog from a wild crucifer *Rorippa indica* (L.) Hiern, is a promising candidate to control mustard aphid *Lipaphis erysimi*. Arthropod-Plant Interactions 12:701–714 (online version https://doi.org/10.1007/s11829-018-9615-z) Impact Factor 1.630.
3. Bose S, Gangopadhyay G and Sikdar SR (2019) *Rorippa indica HSPRO2* expression in transgenic *Brassica juncea* induces tolerance against mustard aphid *Lipaphis erysimi*. Plant Cell Tissue and Organ Culture 136 : 431 – 443 (online version https://doi.org/10.1007/s11240-018-1524-4) Impact Factor 2.200.

Submissions to GenBank, NCBI Database

1. Dutta D and Gangopadhyay G (submission date 22.12.2018) *Sesamum mulayanum* NAC domain-containing protein 43 (NAC43) mRNA, partial cds. GenBank Accession MK333920.
2. Dutta D and Gangopadhyay G (submission date 22.12.2018) *Sesamum mulayanum* V-type proton ATPase subunit C-like protein (VPA) mRNA, partial cds. GenBank Accession MK333919.
3. Dutta D and Gangopadhyay G (submission date 15.12.2018) *Sesamum mulayanum* ferric reduction oxidase (FRO) mRNA, partial cds. GenBank Accession MK300074.
4. Dutta D and Gangopadhyay G (submission date 10.12.2018) *Sesamum prostratum* centroradialis mRNA, partial cds. GenBank Accession MK300073.
5. Awon V K, Dutta D and Gangopadhyay G (submission date 10.12.2018) *Sesamum mulayanum* NBS-LRR class resistance protein mRNA, partial cds. GenBank Accession MK300072.
6. Dutta D and Gangopadhyay G (submission date 10.12.2018) *Sesamum mulayanum* omega 6 fatty acid desaturase (FAD) mRNA, partial cds. GenBank Accession MK300071.
7. Dutta D and Gangopadhyay G (submission date 10.12.2018) *Sesamum mulayanum* polyphenol oxidase (PPO) mRNA, partial cds. GenBank Accession MK300070.

8. Dutta D and Gangopadhyay G (submission date 10.12.2018) *Sesamum mulayanum* sesamin synthase (SS) mRNA, partial cds. GenBank Accession MK300069.

Invited Talks

a. Nominated (by the Director, BI) to act as a mentor in the Science movement programme for the school children (class VII to IX) organized by Shubhadra Charitable Trust, Bhubaneswar (23rd to 24th May 2018). Delivered presentation with demonstration entitled "Plant Sensitivity & Sir J C Bose" on 23rd May 2018.

b. Invited Video presentation entitled "The early expression of *wuschel*, an organ identity gene, is a marker in tobacco and *Beta palonga* during the onset of *in vitro* shoot morphogenesis conditions" in the International Conference on Plant Science (November 15-16, 2018), Paris, France on 16th November 2018.

c. "Akashvani Maitree is a Bengali Channel, a unique venture of All India Radio and is aimed at strengthening ties between the two neighbours India and Bangladesh". On behalf of this channel Ms Oindrila Roy took an interview of Dr Gaurab Gangopadhyay, Associate Professor, Division of Plant Biology on 17.01.2019 at Main Campus, Bose institute. The topic was "Genetically Modified Crop – its present status and the prospect with particular reference to India and Bangladesh". The channel broadcasted it on Monday, 21.01.2019 at 09:00 am and again at 07:45 pm.

Extramural Funding

Project entitled "Development of transgenic pineapple over-expressing AcSERK to combat fungal pathogens" funded by **Department of Biotechnology, Govt of West Bengal** (Memo No. 43(Sanc) – BT/ST/P/S&T/2G-32/2017 dtd **16.02.2018**) for three years.

Awards / Honours / Memberships

Reviewer of the following journals:

- The Nucleus (June 2018, February 2019)
- PLOS ONE (December 2018)
- Indian Journal of Genetics and Plant Breeding (February 2019).

Conference(s) / Workshop(s)

a. Acted as the Resource person (Internal) of Plant Science in the North-Eastern States Students' Training on Basic Science 2018 (NESST-BASE 2018) at Mayapuri Campus of Bose Institute, Darjeeling from 9th May – 10th May 2018. Compiled and prepared the booklet for the trainees.

b. Nominated (by the Director, BI) to attend the India International Science Festival 2018 (IISF 2018) during 5th to 8th October 2018 at Lucknow (office order R/252/18/2157 dtd. 17th September 2018).

c. Nominated (by the Director, BI) to represent Bose Institute in the 14th *Jatiya Sanhati Utsab-o-Bharat Mela* held at Atul Krishna Roy High School, Sonarpur, 24 Parganas (S), WB from 12th to 16th December 2018 (office order R/252/18/3133 dtd. 11.12.2018).

d. Organized the 3rd Hands-on-Training programme on "Basic and Applied Physical and Biological Sciences for the High School Students" at MEF (Madhyamgram Experimental Farm) as 'the Convener' from 18th to 20th December 2018.

e. Nominated (by the Director, BI) to represent Bose Institute in the 5th Tangra Science Fair, organized by Barisha Vigyan O Sanskriti Kendra (VOSK) in association with Bosepara MRITTIKA Krishi Kalyan Samiti, held at Bhutnath Mahamaya Institution, Kolkata - 700015 on 25th January 2019.

f. Oral presentation (by Debabrata Dutta, my Ph. D student) entitled "Molecular breeding for the development of novel inter-specific hybrid sesame to combat changing climate" by D. Dutta, V. Awon and G. Gangopadhyay at the 3rd Agriculture and Climate change conference 24th to 26th March 2019 at Budapest, Hungary (organized by Elsevier Ltd.).

g. Poster presentation (by Vivek Kumar Awon, my Ph. D student) entitled "Growth-promoting rhizospheric fungi to boost the productivity of Darjeeling Tea" by V. Awon, D. Dutta, A. Ghosh and G. Gangopadhyay at the 3rd Agriculture and Climate change conference 24th to 26th March 2019 at Budapest, Hungary (organized by Elsevier Ltd.).

Number of Abstracts (international): two

DR. PALLOB KUNDU
Associate Professor

Name of the Participants

Post Doctoral Scholars: Dr. Jayanti Jodder, Dr. Supriyo Chowdhury, Dr. Arpita Basu Chowdhury

Ph.D. Scholars: Sayani De, Rohit Das, Shreya Chowdhury, Shrabani Basak, Sayan Mal, Himadri Das, Ananya Mukherjee

Short term trainee students: Souradip Paul, Abhisha Roy, Koushambi Mukherjee, Ankita Chattopadhyay, Raghuvir Singh and Ambar Mandal

Background

Investigating gene-regulatory circuit active during biotic stress response in tomato

Plants respond to a stress by reprogramming of existing gene expression cascade to impose robustness and specificity to the response. Regulation of initiation of transcription and microRNA (miRNA)-mediated posttranscriptional gene-silencing have crucial roles in this process. Major information regarding genomic and non-genomic regulations during pathogen stress has been derived from plant-biotrophic pathogen interactions, however, necrotrophic pathogenesis inflicted gene regulations have been explored the least.

Unlike a resistance response against biotrophic pathogen, resulting in hypersensitive response related cell death, necrotrophs induce cell death for deriving nutrients from dead tissues. Genetic resistance against these pathogens is unknown and molecular response to cope the stress remains elusive. Our research focuses on understanding the intricacies of gene regulation mechanisms that actual shape a stress-response during necrotrophic pathogenesis by tomato early blight pathogen *Alternaria solani*. We are also using Tomato leaf curl New Delhi Virus to better understand the overall disease biology and thermal stresses to investigate on the effect of environmental factors in the disease progression.

Emphases are on understanding the major processes of gene regulatory mechanisms such as, regulation of initiation of transcription by transcription factors (TFs) and post transcriptional regulation by miRNAs. Among the TFs we are interested in plant specific membrane-bound NACs, namely, NACMTFs as they may serve as direct sensor of stress on cellular membrane.

Aims and Objectives

- Understanding mechanisms of regulation of *Alternaria* stress-responsive microRNA expression and significance of specific miRNA-mRNA interaction in the disease biology.
- Investigating the role of mediators of cell death, such as NB-LRRs and metacaspases, in disease development.
- Analysing the mechanisms of regulation of expression and biological functions of membrane bound NAC transcription factors in tomato (NAC MTFs)
- Generation of stress resilient crops of the future by biotechnological approaches.

Work Achieved

- Key signalling molecules of *Alternaria*-stress response in tomato have been identified.
- We have confirmed that specific miRNA-target interactions contribute in stress response preparedness in tomato.
- We have shown that MIR167a gene is the major contributor of the miR167 pool in tomato. miR167 expression level was altered at various stresses and during development. Detailed promoter analyses revealed the role of DREB transcription factor in transcriptional regulation. Most important observation was that regulations during processing steps of primary and precursor MIR167s determined the ultimate level of miR167.
- The domain responsible for the membrane localization of tomato NACMTF, SlNACMTF3, has been identified and functionally validated.
- miR6024 overexpression in transgenic tomato has been linked to upregulation of several defense related genes and heightened immune response.
- Expression pattern and mechanism of regulation of tomato TORNADO1 gene, which is directly involved in vein development, during pathogen stress have been uncovered.

Division of Plant Biology

Future Research Plans

- Analysis of miRNA-target interaction in Alternaria pathogen resistant/tolerant line vs. susceptible lines needs to be completed.
- Studies on the understanding of the mechanism of stress-dependent regulation of miR167 precursor-processing are ongoing.
- Two new membrane bound NAC transcription factors (SlNACMTFs) have been identified whose biological role was unknown. Our studies implicated these NAC genes as facilitator of plant stress response. We are investigating the mechanism of their activation during stress and significance in plant stress biology.
- New project has been initiated to develop improved tools for induced genome regulation.

Students Awarded Ph.D.

- Jayanti Jodder (CU, 2018) Regulation of miR-gene expression in response to physiological and environmental stimuli in tomato plant.

Extramural Funding(s)

i. Exploring membrane-associated NAC-transcription factors (NAC MTFs) in tomato to apprehend membrane-mediated signaling during pathogenesis, CSIR, (PI: Pallob Kundu), 4 years, Granted from October 2014.

ii. Genome wide transcriptome analysis to identify MYMIV-stress related genomic resources of blackgram, WB, DBT, (PI: Prof. Amita Pal, Co-Investigator: Pallob Kundu), 3 years (from 2016).

iii. Antimicrobial Peptides Against Crops Disease (PI: Anirban Bhunia, Co PI: Pallob Kundu; Foreign PI: Martin Malmsten) DST, Indo-Sweden, 31.39 lakhs, June, 2017 to May, 2019

iv. Intracellular Dynamics of Small Molecules During Novel AMP-mediated Resilience in Planta: A Multidisciplinary Approach (PI: Anirban Bhunia, coPI: Pallob Kundu, coPI: H. Atreya), DST, 3 Years, June 2018 onwards

v. Developing an optimized toolkit for inducible genome editing and regulation of gene expression in tomato plant: implications in adjusting complex traits via synthetic biology approach" for a period of 3 Years, from DBT, GoI, PI: Pallob Kundu, August 2018 onwards.

DR. SHUBHO CHAUDHURI
Professor

Name of the Participants

Ms. Rwitie Mallik, SRF; Ms. Pratiti Dasgupta, SRF; Ms. Jinia Chakrabarty, SRF; Ms. Sonal Sachdev, JRF; Ms. Ruby Biswas, JRF.

Background

Plants being sessile organisms constantly modify their physiological and developmental processes in response to various environmental cues– a phenomenon which is extremely essential for stress adaptation. The stress signal promote the transcription of plethora of stress responsive genes by inducing changes in chromatin structure either by DNA methylation, histone modifications, small non coding RNA or through DNA-dependent chromatin remodeling, deposition of new histone variants. Stress-induced epigenetic changes in the chromatin can lead to transient response or sustained response where the new chromatin state are maintained as stress memory. It is assumed that the stress memory induced due to epigenetic changes in the chromatin, will provide a "primed state" to plants, for faster and stronger response against subsequent environmental conditions. It will be interesting and challenging to identify the chromatin state (modifications) that can be transferred to the offspring as stress memory for better

stress perception and adaptability. The research in my lab focuses on exploring different epigenetic changes that occur in the genome during abiotic stress response.

Aims and Objectives

- Identify stress induced epigenetic marks that promotes transcription of stress induced genes
- Characterization of plant chromatin modifiers like Trithorax factor ULTRAPETALA and elucidating its role in nuclear organization during plant development and stress response
- Characterization of plant specific nuclear architectural proteins and investigating its role in plant development.

Work Achieved

Rice Trithorax factor ULTRAPETALA 1 (OsULT1) specifically binds to the putative Polycomb response elements "GAGAG" to regulate the cold induced transcription

Ultrapetala, a sand domain containing protein function as plant trithorax factor. Expression of ULT1 increases during stress response. ULT1 directly binds to PRE elements 'GAGAG' present at the promoter region of *OsDREB1b* gene. OsULT1 physically interacts with SET domain containing methyltransferase, OsTRX1 that methylates H3K4me3

Comparative genome wide changes in Histone H3K27 modification and gene expression in rice during cold stress

Low temperature is a major abiotic stress, known to adversely affect the growth and development of rice plants, Oryza sativa. This project involves the study of genome-wide changes in the epigenetic marks of Lysine 27 of Histone H3 and changes in the transcriptome, involved in stress response when rice plants are subjected to cold stress. The acetylation of Lys27 of Histone H3 (H3K27ac) is known to be an activating mark, facilitating transcription, as opposed to the trimethylation of the same residue (H3K27me3), which when present leads to repression of transcription.

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

The plant specific architectural protein ARID/HMG prefer to bind different DNA topological forms and can bent and induce supercoiling. Knockout mutant of ARID/HMG protein AtHMG15 (Arabidopsis HMG15) shows mutant pollen morphology and retarded pollen tube germination.

Future Research Plans

- Genome-wide analysis of Histone H3K27 modifications changes will be carried out to understand the regulation of transcription network of cold response both genetically and epigenetically.
- Isolation and characterization of OsULT1 knock-down and overexpression plants to study the co-ordination between Polycomb group (PcG) and Trithorax group (TrxG) chromatin proteins during salinity stress response.
- Isolation and characterization of AtHMG15 knockout and overexpression to identify pathway(s) responsible for pollen development.

Students Awarded Ph.D

1. Amit Paul (CU, 2018) Investigating The Epigenetic Regulation Involved In The Transcription Of Stress Induced Genes in Oryza sativa L.
2. Anju Patel (CU, 2018) Molecular characterization of a stress responsive Vigna mungo MAP kinase and deciphering its role in MYMIV-resistance.
3. Sayantani Sihi (CU, 2019) Molecular Analysis on Expression of DNA Polymerase Gene and the Enzyme in Different Organs and Stages of Growth and Development in indica rice (Oryza sativa L.).
4. Niti Yashvardhini (CU, 2019) Regulation of Expression And Activity of 14-3-3 Genes and The Protein In Different Rice Cultivars As Affected By Salinity and Drought Stress.

Publications

1. R Mallik, A Kundu, S Chaudhuri (2018) High mobility group proteins: the multifaceted regulators of chromatin dynamics. The Nucleus 61 (3), 213-226.
2. D Roy, J Chakrabarty, R Mallik, S Chaudhuri (2019) Rice Trithorax factor ULTRAPETALA 1 (OsULT1) specifically binds to "GAGAG" sequence motif present in Polycomb response elements. Biochimica et Biophysica Acta (BBA)-Gene Regulatory Mechanisms 1862 (5), 582-597.

Book Chapters

1. P Dasgupta, S Chaudhuri (2019) Analysis of DNA Methylation Profile in Plants by Chop-PCR. Plant Innate Immunity, 79-90.
2. A Paul, S Chaudhuri (2019) Change in Nucleosome Dynamics During Stress Responses in Plants. Plant Innate Immunity, 91-100.

Invited Talk

Delivered a lecture at 18th All India Congress of Cytology and Geneics and International symposium on "Translating Gene and Genome" jointly organized by CSIR-IICB and Archana Sharma Foundation of Calcutta. 2018.

Extramural Funding(s)

- Unraveling the role of PLC in plant drought and heat stress tolerance :Exploring the potential of PI metabolism to improve crop yield. (DBT-NOW; PI: Prof ANL Majumber: CoPI: Shubho Chaudhuri).
- Investigating the role of Arabidopsis ARID-HMG protein, AtHMGB15, in the pollen development. (SERB, PI: Shubho Chaudhuri).
- Investigating the role of Trithorax factor ULTRAPETALA1 in salt stress response in rice. (WB-DBT: Shubho Chaudhuri).

Conference(s) / Workshop(s)

- Poster participations in the Indo-Japan Conference on "Epigenetics and Human Disease" organized by Bose Institute and Indo-Japan Forum for Advanced study 2018.
- Poster presentation on "Genome-wide analysis of the changes in Histone H3K27 modifications and gene expression in rice during cold stress" at Keystone symposia on "Chromatin Architecture and Chromosome Organization" Whistler, British Columbia, Canada, 2018.

Scientific Report : Senior Scientists

PROF. A.N.LAHIRI MAJUMDER

INSA Senior Scientist
(upto February 28,2019);
INSA Honorary Scientist
(Since March 01, 2019)

Area of Research

Abiotic stress tolerance in plants: Regulation of inositol and phosphoinositide metabolism.

The laboratory had been engaged primarily in the following investigations:

- The study & manipulation of pathways of the phosphoinositide and inositol metabolism and transgenic overproduction of stress regulated genes in rice. To this effect, PcINO1 and PcIMT1 genes have been successfully introgressed in IR64 rice and homozygous salt-tolerant lines have been obtained. Phosphoinositide catabolising Phosphlipase C genes have been studied with respect to their gene structure and expression during salinity/drought stress and are currently being introgressed in transgenic rice for overexpression for their phenotype under stress.
- Regulation of expression of galactinol synthase genes through abiotic stress regulated intron retention in rice has been established.
- Promoters of the MIPS coding *INO1* genes from the halophytic wild rice have been characterized.
- Transcriptome analysis of grapevine under salinity stress and identification of key-genes for salt-tolerance have been achieved.
- Diversity in a large number of rice landraces have been analysed with respect to their salinity tolerance *vis-a-vis* root behaviour under mechanical stress.
- Collaborative work with other investigators for studies on endophytic bacterial consortia for arsenic phytoremediation in other crop plants were undertaken.

Publication(s)

1. Das P, Majumder A L (2018) Transcriptome analysis of grapevine under salinity and identification of key genes responsible for salt tolerance. Functional & Integrative Genomics, 19(1):61-73.
2. Basak P, Sangma S, Mukherjee A, Agarwal T, Sengupta S, Ray S, Majumder A L (2018) Functional characterization of two myo-inositol-1-phosphate synthase (MIPS) gene promoters from the halophytic wild rice (Porteresia coarctata). *Planta*, 248(5): 1121–1141.
3. Mukherjee S, Sengupta S, Mukherjee A, Basak P , Majumder A L (2018) Abiotic stress regulates expression of galactinol synthase genes post-transcriptionally through intron retention in rice. *Planta*, 249 (3): 891–912.
4. Mukherjee G, Saha C, Naskar N, Mukherjee A, Mukherjee A, Lahiri S , A L Majumder and Seal A (2018) An Endophytic Bacterial Consortium modulates multiple strategies to improve Arsenic Phytoremediation Efficacy in *Solanum nigrum*. *Scientific Reports*. 8:6979 DOI. 10.1038/s41598-018-25306-x.
5. Mukherjee R, Mukherjee A, Bandyopadhyay S, Mukherjee S, Sengupta S, Ray S and Majumder A L (2019) Selective manipulation of the inositol metabolic pathway for induction of salt-tolerance in *indica* rice variety. *Scientific Reports*, DOI: 10.1038/s4159A-019-41809-7.

PROF. DIPANKAR HOME
NASI Senior Scientist
Platinum Jubilee Fellow

Background

In recent years, exploration of the possible use of separable states as a resource to achieve quantum information processing (QIP) tasks has been gaining increasing significance. In this context, a particularly important demonstration has been that nonvanishing discord is the necessary condition for separable states to be used as a resource for remotely preparing any arbitrary pure target state [Nat. Phys. 8, 666 (2012)].

Objective

The present work stems from our observation that not only can resource states with the same discord imply different efficiencies (in terms of average fidelity) of the remote state preparation (RSP) protocol, but also states with higher discord can imply lower RSP efficiency. Therefore, this necessitates identification of the relevant feature of quantum correlations that can appropriately quantify the effectiveness of the resource state for the RSP protocol.

Work achieved

To this end, for the two-qubit Bell-diagonal states, we show that an appropriate measure of simultaneous correlations in three mutually unbiased bases can serve to quantify the usefulness of the resource for the RSP task using entangled as well as separable states, including nondiscordant states as a resource. In particular, it is revealed that zero-discord states with such a nonvanishing measure can be useful for remotely preparing a subset of pure target states. Thus, this work shows that, using separable states, an effective resource for QIP tasks such as RSP can be provided by simultaneous correlations in mutually unbiased bases.

Background

The present work is motivated by the question what aspect of correlation entailed by the two-qubit state serves as the appropriate quantitative resource for steering.

Objective

To this end, considering Bell-diagonal states, suitable measures of simultaneous correlations in two and three complementary (mutually unbiased) bases are identified as the relevant resources for quantum steering.

Work achieved

Quantitative relations between appropriate measures of quantum steering and corresponding measures of simultaneous correlations in complementary bases are demonstrated which ensure that for two-qubit steerable Bell-diagonal states, a higher value of simultaneous correlations in mutually unbiased bases necessarily implies a higher degree of quantum steering, both for two- and three-setting steering scenarios.

Objective

Can the most "classical-like" of all quantum states, namely the Schrödinger coherent state of a harmonic oscillator, exhibit nonclassical behavior?

Work achieved

We find that for an oscillating object initially in a coherent state, merely by observing at various instants which spatial region the object is in, the Leggett-Garg inequality (LGI) can be violated through a genuine negative result measurement, thereby repudiating the everyday notion of macro realism. This violation thus reveals an unnoticed nonclassicality of the very state which epitomizes classicality within the quantum description. It thus opens up potentially the simplest way (without coupling with any ancillary quantum system or using nonlinearity) for testing whether various recently engineered and sought after macroscopic oscillators, such as feedback cooled thermal trapped nanocrystals of ~106–109 amu mass, are indeed bona fide nonclassical objects.

Publication(s)

1. Kanjilal S, Khan A, Jebarathinam C, and Home D (2018) Remote state preparation using correlations beyond discord; *Physical Review* A 98, 062320.
2. Jebarathinam C, Khan A, Kanjilal S and Home D (2018) Revealing the quantitative relation between simultaneous correlations in complementary bases and quantum steering for two-qubit Bell diagonal states; *Physical Review* A 98, 042306.
3. Bose S, Home D and Mal S (2018) Nonclassicality of the harmonic-oscillator coherent state persisting up to the macroscopic domain; *Physical Review Letters* 120, 210402.

Scientific Report : Senior Scientists

Extra Mural Funding(s)

(a) Co-investigator of the Research Project titled "*Applications of Quantum Information*", under the "Quantum Enabled Science & Technology" initiative of the Dept. of Science and Technology, Govt. of India; jointly with Prof. Archan S. Majumdar of S N Bose National Centre of Basic Sciences, Kolkata as Principal Investigator.

(b) Co-investigator of the India-Trento Programme for Advanced Research titled "*A cheap, light, compact source for QKD based on intraparticle entanglement in an integrated photonic circuit*" funded by the Dept. of Science and Technology, Govt. of India; jointly with Prof. Urbasi Sinha of Raman Research Institute, Bangalore as Principal-investigator.

PROF. JOYOTI BASU

J. C. Bose National Fellow

The role of the transcription factor, ATF3 in the regulation of the host response to *Mycobacterium tuberculosis* infection : *In collaboration with Prof. Manikuntala Kundu, Dr. Zhumur Ghosh, Dr. Kuladip Jana and Dr. U. D. Gupta, National Jalma Institute of Leprosy and Other Mycobacterial Diseases, Agra.*

Infection of macrophages by *Mycobacterium tuberculosis* elicits an immune response that usually clears the bacterium. However, the bacterium is at times able to subvert the innate immune response and reside within these phagocytic cells. Transcription factors regulate the production of antibacterial effector molecules such as nitric oxide (NO) and proinflammatory cytokines such as tumor necrosis factor (TNF). Infection also induces formation of lipid bodies (LBs) which store cholesterol and neutral lipids, and are important regulators of host-pathogen interactions. Here we assessed the role of the transcription factor ATF3 in the inflammatory response and in LB formation. ATF3 was upregulated early during infection of macrophages or of mice. Of significance, knock down of ATF3 enhanced mycobacterial survival in macrophages suggesting its host-protective role. Strikingly, ATF3 exerts opposing effects on the expression of proinflammatory genes and the formation of LBs in infected macrophages. We demonstrate early growth response protein 1 (EGR1)-dependent upregulation of ATF3. ATF3 directly interacts with chromatinremodeling protein brahma related gene 1(BRG1) during infection, promoting the expression of proinflammatory genes and the production of nitric oxide. ATF3 and BRG1 associate with the promoters of IL-12p40, IL-6 and nitric oxide synthase 2(NOS2), and are linked to their upregulation during infection. On the other hand, ATF3 negatively regulates LB formation. Knock down of ATF3 upregulates expression of cholesterol 25 hydroxylase (Ch25h) and microRNA-33 (miR-33). ATF3 associates at the upstream regions of these two positive regulators of LB formation, Ch25h and the miR-33 locus, and attenuates their expression. Further, ATF3 repressed the association of the activating mark, acetyl histone

H4 lysine 8 (H4AcK8) at the promoter of Ch25h. Taken together our results demonstrate opposing roles of ATF3 in regulation of distinct sets of macrophage genes during mycobacterial infection, converging upon a host-protective immune response. It is likely that ATF3 forms different molecular complexes at different loci to elicit an immune response favoring the host .

The role of the sensor kinase MtrB in *Mycobacterium tuberculosis* infection

We collaborate with Prof. ManikuntalaKundu in understanding the role of two component signal transduction systems (TCSs) in the pathogenesis of tuberculosis. The TCSs of *Mycobacterium tuberculosis* sense and respond to the external milieu enabling the bacterium to survive within its host. Paired TCSs have a sensor kinase (SK) and a cognate response regulator (RR) usually in the same operon. Although transcriptional activation of the paired MtrABTCS has been reported during *M. tuberculosis* infection of phagocytic cells, its role in infection remains poorly understood. We show that genetic disruption of MtrB compromises the hypoxic response, central carbon metabolism, energy homeostasis and biofilm formation in *M. tuberculosis*. Additionally we observed that the absence of MtrB attenuates the expression of cell division, peptidoglycan and mycolic acid synthesizing genes compromising cell wall homeostasis and altering cell morphology. We also demonstrate that MtrB is required for subversion of trafficking of *M. tuberculosis* to host autophagosomes and lysosomes and bacterial survival in macrophages. Together, these findings underscore the hitherto unknown, novel function of MtrB as a global regulator that is central to the ability of *M. tuberculosis* to withstand stress and to survive in the host environment.

Publication(s)

Datta C, Subuddhi A, Kumar M, Lepcha TT, Chakraborty S, Jana K, Ghosh Z, Mukhopadhyay AK, Basu J, Kundu M (2018) Genome wide mRNA–miRNA profiling uncovers a role of themicroRNA miR-29b-1-5p/PHLPP1 signalling pathway in *Helicobacter pylori* driven matrix metalloproteinase productionin gastric epithelial cells. *Cell Microbiol.*, 20(9), e12859.

Conferences/ Symposia / Workshops

a. Delivered a lecture in the conference *"XII Congress of the Latin American Association of Immunology (ALAI)" being organized by* Latin American Association of Immunology *held in Cancun,* Quintana Roo, Mexico, May 14-18, 2018.

b. Delivered a lecture in the meeting "Genome Biology; mechanisms in Health and Disease" held at the Indian Institute of Science, Bangalore from July 13 to 14, 2018.

c. Delivered a lecture in the Diamond Jubilee Symposium held in the Department of Biosciences and Bioengineering, IIT Bombay on 15 and 16 February, 2019.

Students Awarded Ph.D.

1. Sanjaya Kumar Sahu (C.U., 2018) "Understanding the regulation of immune response genes in *Mycobacterium tuberculosis*-infected macrophages".
2. Manish Kumar (C.U., 2018) "Post transcriptional regulation of macrophage signaling pathways by *Mycobacterium tuberculosis*"
3. Ayan Chatterjee (C.U., 2018), as Joint Supervisor with Prof. Manikuntala Kundu (Supervisor) "The role of two component system dependent signal transduction in mycobacterial"

PROF. PINAKPANI CHAKRABARTI
J. C. Bose National Fellow

Effect of nanoparticles on the growth of bacteria and the structure and function of model proteins

We have been studying the effect of ZnO, gold and silver nanoparticles (NPs) on the growth of different biotypes of *Vibrio cholerae*, and shown how the size and morphology can affect the behaviour of NPs. Along this line we used ZnO coated iron oxide nanotextured composites to examined the effect on classical and El Tor biotypes of *V. Cholera*, and modelled the growth kinetics. In a different study we investigated how graphene oxide (GO) affects the structure and activity of a model protein, hen egg white lysozyme – it was shown that the NP-binding does not cause much change in the structure, but the catalytic activity is reduced significantly. Fluorescence and theoretical studies suggest that GO binds at or near the active site affecting the flexibility of the surrounding residues and thus contributing to the reduction of the activity.

Structural changes accompanying protein-DNA complex formation

To delineate features that characterize protein-protein interactions is a long-standing theme in our group. We have extended the work to protein-DNA interaction, and analyzed the unbound (U) and the bound (B) forms of proteins in 66 binary protein-DNA complexes. Proteins binding DNA undergo greater structural changes on complexation (in particular, those in the enzyme category) than those involved in protein-protein interactions (PPI). While interface atoms involved in PPI exhibit an increase in their solvent-accessible surface area (ASA) in the bound form in the majority of the cases compared to the unbound interface, protein-DNA interactions indicate increase and decrease in equal measure. In 25% structures, the U form has missing residues which are located in the

interface in the B form. Consideration of flexibility cannot distinguish the interface residues from the surface residues in the U form.

Structural motif, *Topi* and its role in protein function and fibrillation

From the analysis of protein structures, a structural motif, *topi*, has been identified in which a pair of 2-residue segments, each containing hydrogen-bonded five-membered fused-rings motifs, distant in sequence are linked to each other by a hydrogen bond. The motif can be found near the active site and also in the disease-causing misfolded proteins, such as fibrilled form of A 42. It may thus be an important component of fibrillation.

The role of isoaspartate in fibrillation and its prevention by Protein-*L*-isoaspartyl methyltransferase (with Dr. Tanaya Chatterjee, DST Woman Scientist)

A hexapeptide, Val-Tyr-Pro-(isoAsp)-His-Ala (VA6), a substrate of Protein-*L*-isoaspartyl methyltransferase (PIMT), has been shown to form fibrils, while the normal Asp-containing peptide does not. Interestingly, two antiepileptic drugs (AEDs), valproic acid and stiripentol, were found to enhance the activity of PIMT. Studies with PC12 derived neurons showed that PIMT and PIMT/AEDs exerted neuroprotective effect against anti-NGF induced neurotoxicity. This was further validated against neurotoxicity induced by A 42 in primary rat cortical neurons. Furthermore, Ab42, implicated in Alzheimer's disease, undergoes b-sheet to a-helix transition in presence of PIMT. Furthermore, Ab42, implicated in Alzheimer's disease, undergoes b-sheet to a-helix transition in presence of PIMT. IsoAsp, with an additional C atom in the main-chain of polypeptide chain, may make it more susceptible to fibrillation. PIMT alone, or in association with AEDs may prevent this.

Publication(s)

1. Bera S, Dhar J, Dasgupta R, Basu G, Chakraborti S and Chakrabarti P (2018). Molecular features of interaction involving hen egg white lysozyme immobilized on graphene oxide and the effect on activity. *Int J Biol Macromol*, 120, 2390-2398 (doi: 10.1016/j.ijbiomac.2018.09.007).
2. Dhar J and Chakrabarti P (2018). Structural motif, *topi* and its role in protein function and fibrillation. *Mol. Omics*, 14, 247-256. (DOI: 10.1039/c8mo00048d)
3. Jana TK, Jana SK, Kumar A, De K, Maiti R, Mandal AK, Chatterjee T, Chatterjee BK, Chakrabarti P and Chatterjee K (2019). The antibacterial and anticancer properties of zinc oxide coated iron oxide nanotextured composites. *Colloids and Surfaces B: Biointerfaces*, 177, 512-519 (doi:10.1016/j.colsurfb.2019.02.041).
4. Podder S, Chakravarty D and Chakrabarti P (2018). Structural changes in DNA-binding proteins on complexation. *Nucleic Acids Res*. 46, 3298-3308 (doi: 10.1093/nar/gky170).

Group Members

Scheme funded by DST-Women Scientists Scheme

Dr. Tanaya Chatterjee (Biochemistry): Anti-fibrillation activity of human Protein-L-isoaspartyl-methyl transferase (PIMT) and its modulation in presence of nanoparticles.

Conferences/ Symposia / Workshops

1. Presented paper at (i) the 11th National Symposium cum Workshop on "Recent trends in structural bioinformatics and computer aided drug design", Department of Bioinformatics, Alagappa University. Koraikudi, February 12-15, 2019.
2. Chaired a session at (ii) AsCA2018 (the Annual Meeting of the Asian Crystallographic Association) held at Auckland, New Zealand, December 2-5, 2018.
3. Convener and a resource person at the (iii) Science Academies Lecture Workshop on 'Chemistry of Non-covalent interactions – Strength in Weakness,' held at Jhargram Raj College, February 5-7, 2019.

PROF. PROBIR ROY
INSA Senior Scientist

CP-transformed mixed mt antisymmetry of neutrinos and consequences : *In collaboration with Roopam Sinha and Ambar Ghosal of Saha Institute.*

We propose a complex extension of mixed antisymmetry in the neutrino Majorana mass matrix M . This can be implemented in the Lagrangian by a generalized CP transformation (labeled by a mixing parameter) on the left-chiral flavor neutrino fields. We investigate its implications for leptonic CP violation and neutrino phenomenology in general. Interestingly, the mt mixing parameter gets correlated with the Dirac CP phase and the atmospheric mixing angle $_{23}$ through an analytical relation. In general, for arbitrary , both $_{23}$ and are nonmaximal. We discuss the corresponding results for the CP asymmetry parameter A_{e} in neutrino oscillation experiments. For a nonmaximal , one of the two Majorana phases is different from 0 or , thereby leading to nonvanishing Majorana CP violation with observable consequences for the neutrinoless double beta (0) decay process. We numerically work out in detail the predictions for that process in relation to various ongoing and forthcoming experiments. We also work out the predictions of our scheme on flavor flux ratios at neutrino telescopes. While exact CP transformed interchange antisymmetry (= /2) leads to an exact equality among those ratios, taking a value 0:5, a tiny deviation can cause a drastic change in them. Careful measurement of these flux ratios in future will further constrain the parameter .

PROF. SAMPA DAS
INSA Senior Scientist

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

Scientific Report

Chickpea, the third most globally important pulse crop with excellent nitrogen fixing machinery suffers from various pests and pathogens attack, of which wilt disease caused by *Fusarium oxysporum* is highly significant. Resistance development in this crop is difficult due to non-availability of appropriate resistant gene(s). We employed transcriptomic approach to understand defense response mechanism in chickpea against the pathogen. Among several stress induced transcription factors, WRKYs were found to be global regulators of immunity in both plants and animals. In chickpea-Fusarium interaction, particularly WRKY40 was found to play crucial role in resistance response. CaWRKY40 overexpressing chickpea mounts resistance to Foc1 by positively modulating the defense related gene expression. Our study resolved that in present interaction CaMAP Kinase9 phosphorylates CaWRKY40 at two canonical serine residues which is essential for triggering resistance response. Overexpression of mutated wrky40 (at two serine residues) failed to exhibit any resistance in chickpea.

Publication(s)

In Referred Journals:

1) Chakraborty J, Priya P, Ghosh Dastidar S, Das S (2018) Physical interaction between nuclear accumulated CC-NB-ARC-LRR protein and WRKY64 promotes EDS1 dependent *Fusarium* wilt resistance in chickpea. *Plant Sci*. 276:111-113 [Impact Factor 3.437]

2) Chakraborty J, Ghosh P, Sen S, Das S (2018) Epigenetic and transcriptional control of chickpea WRKY40 promoter activity under *Fusarium* stress and its heterologous expression in *Arabidopsis* leads to enhanced resistance against bacterial pathogen. *Plant Sci*. 276:250-267 [Impact Factor 3.437]

3) Chakraborty J, Ghosh P, Das S (2018) Autoimmunity in plants. *Planta* 248:751-767 [Impact Factor 3.24]

4) Chakraborty J, Ghosh P, Sen S, Nandi A K and S Das CaMPK9 increases the stability of CaWRKY40 transcription factor which triggers defence response in chickpea upon *Fusarium oxysporum* f. sp. ciceri Race1 infection. *Plant Molecular Biology* (2019) DOI 10.1007/s11103-019-00868-0. [Impact Factor 3.92]

5) Das S and S Das, First report of a novel alphapartitivirus in the basidiomycete *Rhizoctonia oryzae-sativae*. Archives of Virology 164 (3) (2019) : 889-892 doi.org/10.1007/s00705-018- 04116-6 [Impact Factor 2.134]

Book Chapters

1. Jain A and Das S (2018) Biosafety and regulatory aspects of nanotechnology in agriculture and food. In Emerging trends in agri-nanotechnology: fundamental and applied aspects, Edited by H.B. Singh et. Al., CABI, PP. 263-270.

2. Jain A, and Das S (2019) Fungal diseases of some important medicinal plants. In Diseases of Medicinal and Aromatic Plants and their Management. pp. 187-198. Edited by R. Pandey, A.K. Misra, H. B. Singh, A. Kalra and D. Singh (Indian Phytopathological Society, 2019)

Conferences / Symposia / Workshops

1. Delivered a talk entitled **"** Plants' Immune Response : Chickpea-Fusarium Interplay, a Case Study" in Prof. A. K. Sharma Memorial Symposium on "Recent Advances in Plant Science Research" Organized by NASI, Kolkata Chapter and CSIR-IICB, Kolkata on 18th September, 2018 at IICB, Kolkata

2. Delivered two talks entitled "Understanding of promoter activity of certain plant transcription factors under stress : A case study of Chickpea – Fusarium interaction" and " Prospects and challenges of insect resistant crop development" in the Winter School in Environment Planning & Management event on 10th December, 2018 at Burdwan University organized jointly by UGC - HRDC, BU

Students Awarded Ph.D. degree

Joydeep Chakraborty (CU, 2018) Molecular approaches for developing tolerance in chickpea to Fusarium infection and pod borer infestation

Group Members

Dr. Akansha Jain has been working as DST Young Scientist (YSS/2015/000773) till 19.11.18 on a project entitled "Proteomics approach to study the resistance response induced in rice treated with beneficial microbes upon challenge inoculation with *Xanthomonas oryzae*."

Microbial consortium consisting of *Bacillus amyloliquefaciens* and *Aspergillus spinulosporus* upon recruited in rhizosphere of rice enhanced disease resistance symptom against *Xanthomonas oryzae* suggesting the induction of systemic signals to the whole plant which promotes plant growth and enhances protection against bacterial blight infection.

Dr. Sathi Paul is continuing as CSIR Associate (since 01.05.18) on a project entitled **"**Efficacy of monomeric mutant variant of *Allium sativum* leaf agglutinin (mASAL) against wilt causing root pathogen *Fusarium oxysporum* f. sp. *ciceri* (Foc) of chickpea (*Cicer arietinum* L.)"

PROF. SUSHANTA DATTAGUPTA
FNA (INSA Senior Scientist)

During this year I continued on research in the area of Quantum Effects in Solids, with special reference to Nano-Science. Some have already been published during this period (with details given below) while others are being either submitted or being written up. The latter include a review paper on: Carbon Hybridization to Tight-Binding to Dirac Solid – the Wonder World of Graphene (submitted to Resonance), Ericsson-Brownian Engine, with S. Chaturvedi (in preparation) and Nonlinear Optical Conductivity in Graphene, with M. Singh (in preparation).

Publication(s)

In Research Journals:

1. Aharony A, Entin-Wohlman O, Chaudhuri D and Duttagupta S (2019) Quantum Phase and its Measurable Attributes *a la* the Aharonov-Bohm Effect, Resonance, . Noise a Good Model for the Environment of Mesoscopic Systems?, *Journal of Statistical Physics, in memory of Pierre Hohenberg,* Springer-Verlag, published on line.
2. Duttagupta S (2019) Cyclotron Motion and the Enigma of Orbital Magnetism – What Does the Boundary Do?, *Proceedings of the Indian National Science Academy*.

Others

Duttagupta S (2019) Foreign Policy Values (with special reference to U. S. A.), in Values in Foreign Policy, ed. Krishnan Srinivasan et al, published on-line.

Conferences/Symposia

1. Delivered Plenary Talk on Pattern Formation in Nonlinear Reaction-Diffusion Equations , at an International Conference on Nonlinear Dynamics (11 – 14 October 2018), at Jawaharlal Nehru University, New Delhi

2. Delivered a series of 6 lectures on GRAPHENE, at the Indian Institute of Science Education and Research, Mohali from 22 – 31 October 2018.
3. Delivered Colloquium on Saha Ionization Equation, Jawaharlal Nehru Centre for Advanced Scientific Research, Bangalore on 12 November 2018.
4. Delivered a series of 5 lectures on GRAPHENE and a special lecture on the Aharonov-Bohm Effect, Jawaharlal Nehru Centre for Advanced Scientific Research, Bangalore from 15 – 21 November 2018.
5. Delivered Colloquium on the Saha Ionization Equation, Department of Physics, Benares Hindu University, Varanasi on 05 March 2019.
6. Seminar on the Aharonov-Bohm effect and its Measurable Attributes, Department of Physics, Benares Hindu University, Varanasi on 07 March 2019.

Central Instruments Facility

(http://www.jcbose.ac.in/cif)

The main hall of CIF at the Centenary Campus

The Central Instrument Facility (CIF) 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 instruments but also advise research students about how to use them effectively.

Most of these instruments are housed in the centenary campus at Bose Institute, but a few are present in the main campus. The facility is extensively used by not only in-house scientists, but also those who belong to universities, colleges and research institutes located in the eastern part of the country. Every year the facility receives numerous visitors, particularly student groups coming from schools and colleges. The technicians interact with the young visitors and help them understand how the instruments function. The facility is expected to expand substantially in the near future, as the institute undertakes new programs in evolving areas such as microbiome research, systems biology and traditional medicines.

The Ion S5 sequencing platform introduced recently was utilized for the whole genome sequencing of 42 bacterial strains and bacteriophages, plus the sequencing of 30 16S rRNA gene pools amplified from diverse environmental samples and consortium-cultures. These bacteria were isolated from various environments such as industrial/municipal waste disposal sites, Sundarban biosphere reserve, marine sediment etc. A workshop on NGS was also held attended by about 40 participants from all over the country.

Among the equipment that are heavily used, the capillary DNA sequencer deserves special mention. On an average 8000 samples are analyzed every year. In recent times the LC-MS-MS and MALDI TOF-TOF facilities are in high demand both among the in- house as well as external users. The number of external users is increasing every year. In the last financial year 260 users from 50 different institutions used the facility resulting in revenue generation of about Rs 7 lakhs.

Instruments:-

1. FACS,
2. Confocal Microscope,
3. DNA Sequencer,
4. GC-MS,
5. HPLC,
6. NMR 500Mhz & 700Mhz
7. Maldi TOF/TOF,
8. RT-PCR,
9. Circular Dichroism spectrophotometer
10. Gel Doc, XR+,
11. Fluorescence spectrophotometer,
12. NGS Ion Torrent
13. LC-MS
14. SEM
15. Liquid Scintillation counter (PerkinElmer)
16. FPLC
17. Peptide Synthesizer
18. AAS
19. Single Protein Crystal Diffractometer(XRD)
20. FTIR

Major facilities at CIF. Clockwise from left, LC-MS-MS, MALDI TOF-TOF, Ion S5, NMR 700 MHz, FACS verse, Typhoon scanner

Outreach programs and training sessions

(Left) College students being briefed about CIF and (Right) workshop on NGS in progress.

Committee Members:

Dr. Sujoy Das Gupta, In- Charge Centenary Campus; Dr. T.P. Sinha, In- Charge Main Campus; Dr. Gourisanker Sa; Dr. Goutam Basu; Dr. A B Dutta; Dr. Debabrata Basu; Dr. Jayanta Mukhopadhyay; Dr. Tapan Dutta; Dr. Pallab Kundu

Central Instruments Facility

Staff Members

Mrs. Tanima Modak Dhar, Technical Officer – I; Mr. Ranjan Kumar Dutta, Technical Officer –I; Mr. Smriti Ranjan Maji, Technical Officer-I; Mr. Mrinal Das, Technical Officer–I; Mr. Swaroop Biswas, Senior Laboratory Assistant; Mrs. Sheolee Ghosh Chakraborty, Senior r Laboratory Assistant; Mr. Amarandra Nath Biswas, Senior Laboratory Assistant; Mr. Pallab Chakraborty, Senior Laboratory Assistant; Mr. Souvik Roy, Senior Laboratory Assistant; Mrs. Alpana Chattopadhaya, Office Staff

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

Falta Experimental Farm

Rural Biotechnology Programmes

On the onset of the Scheduled Tribe Specific Rural Biotechnology Programme (STSRBP), funded by Department of Science and Technology, Government of India, Falta Experimental Farm has become the nodal Centre for carrying out various activities and implementation of the project. The main objectives of this project are to uplift the socio-economic condition, generation of awareness, empowerment of women of the Scheduled Tribe people in West Bengal. The major programmes through which BI extend the support to the ST rural people are viz, Agriculture, Orchard, Mushroom cultivation, Vermicompost production, Fishery, Apiculture, Piggery, Food Processing, Goat rearing, Rainwater harvesting for agriculture as well as drinking purpose, Country chicken rearing, Betel Leaf Cultivation, Crab Culture etc. In this connection, over the years Bose Institute with the help from STSRBP has developed some facilities at Falta Experimental Farm, which are required for carrying out training and generation of awareness of the rural ST people. Furthermore, training of the Project Supervisor andVillage trainers through experts and Master Trainers as well as conducting animal health camps and awareness camps with the help

Falta Experimental Farm

of BDOs & BLDOs of Govt. of West Bengal are very often conducted under this programme.Throughout the year about 151 personnel as and Village Trainer function in coordination with Master Trainers to aware village people about various income generation programs and its successful implementation among the villagers.This programme is spread over 13 districts of West Bengal namely Birbhum, South 24 Parganas, Purulia, Bankura, Jhargram, PaschimMedinipur, PurbaBardhaman, Murshidabad, DakshinDinajpur, Nadia, Hooghly, North 24 Parganas, PurbaMedinipur. At present, about 5500 beneficiaries are associated with this programme through its various activities.

Fig-1: A) Mushroom Cultivation at Falta. B) Fish Breeding Programme C) Mushroom Training programme D) Practical & demonstration class of Vermicompost training programme at FEF.

Fig-2: A) Sunflower cultivation in agriculture land at FEF. B) Women beneficiaries are operating Beekeeping box independently. C) and D) Mr. S. Roy Chowdhury demonstrates the procedures of Fish breeding and Apiculture program.

Falta Experimental Farm

Fig-3: A) Prof. Debabrata.Basu, Co-ordinator of ST-SRBP inaugurates the Poush Mela Exhibition (23 rd – 28 th December 2018) at Shantiniketan, Bolpur. B) Prof. Sujay Dasgupta, Director (Officiating) delivers his important speech in Poush Mela Program. C) People are gathering to know scientific approaches applied in Rural Biotechnology Programme. D) Presentation of Live-Model of Rural Biotechnology Programme at Poush Mela.

Fig-4: A) Field visit of ST-SRBP by Prof. D. Basu at Birbhum district. B) Prof. D.Basu &Dr.Pallob Kundu with projects staffs were visiting Betel Leaf Cultivation Program at Satyadaspur of Sundarban belt. C) A village-level meeting cum Awareness programme at Birbhum District. D) Prof. D.Basu & Dr.Pallob Kundu interacting with the beneficiaries of green chilly cultivation.

Falta Experimental Farm

Fig-5: Awareness meeting about Rain Water Harvesting Programme for Drinking purpose at Bhutadih village, Manbazar-II, Purulia. B) NGO visit at Birbhum C) Rain Water Harvesting programme for Agriculture irrigation by making concrete pond D) Villagers are catching fishes from the community pond at Satyadaspur village, Sundarban.

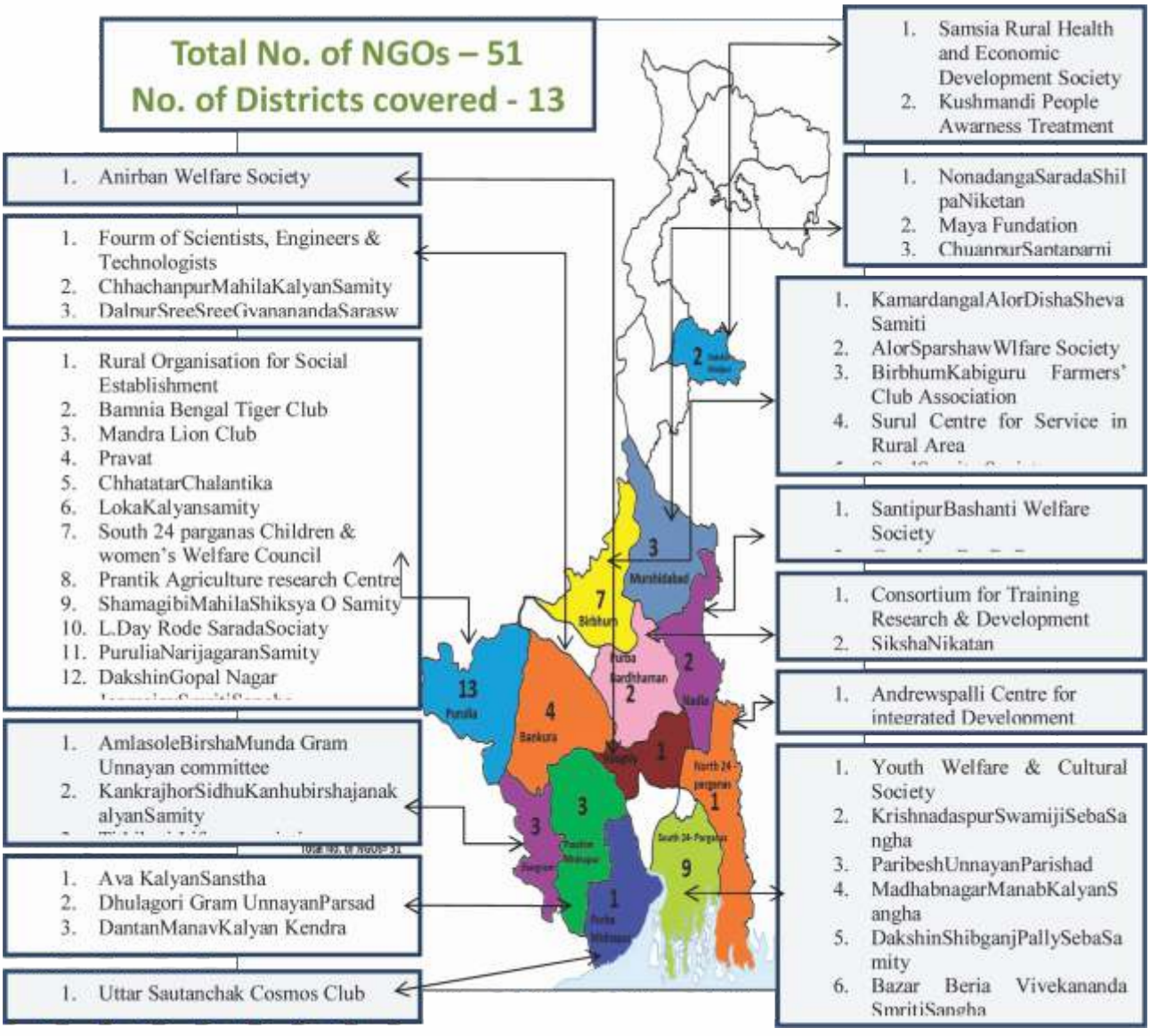


Fig-6: Schematic representation of ST-Specific Rural Biotechnology Programme indicating the locations of work and NGOs involved in different districts of West Bengal.

J. C. Bose Centre

(Museum and Publication Unit)

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; Nivedita Commemoration Volume Rs. 500.00; D.M. Bose-A Scientist Incognito Rs. 350.00; Basu Vigyan Mandir –o-Amar Karmojibon Rs. 200.00.

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

Tarun Kumar Maji, Amitava Bhattacharyya and Ishani Chatterjee participated at the 22nd National Science Exhibition at Milan Samity Maidan, Nimta, Kolkata during August 3-6, 2018.

Gaurab Gangopadjhyay, Tarun Kumar Maji, Jadab Kumar Ghosh, Ishani Chatterjee and Rajbrat Ram participated at the 4th India International Science Festival (IISF-2018) at Lucknow held during October 5-8, 2018.

Gaurab Gangopadjhyay, Tarun Kumar Maji, Jadab Kumar Ghosh and Ishani Chatterjee participated at the 14th Jayiya Sanhati Utsab-o-Bharat Mela at Chandmari,Sonarpur, South 24 Pgs held during December 12-16, 2018.

Tarun Kumar Maji, Amitava Bhattacharyya, Ishani Chattetjee, Rajbrat Ram and C.K. Sasmal participated at the 43rd International Kolkata Book Fair 2019 held at Central Park Mela Ground, Salt Lake during Januray 30- February 10, 2019.

Staff Members : Tarun Kumar Maji, Ishani Chatterjee, Chandra Kanta Sasmal.

Participated at the 43rd Kolkata International Book Fair 2019

Acharya J. C. Bose Biotechnology Innovation Centre

(Madhyamgram Experimental Farm)

Introduction

Madhyamgram Experimental Farm (MEF) is the translational research hub of Bose Institute. Its main component is the agricultural fields where the plant scientists grow their experimental crops in different season for seed multiplication, collection of specific plant parts other than seeds, selfing and to raise selfed seeds, hybridization between desired parents, the study of agro-morphology etc. The inclusion of the J C Bose Innovation Centre in MEF is a relatively recent one (since 2006-2008). The said Centre comprises of Transgenic Plant Research Laboratory (inaugurated on 30th November 2006) and Greenhouses. The Greenhouses are presently fourteen in number, some of which are dedicated to transgenic plant research, while the rest are for routine hardening and transplantation of tissue culture plantlets. The laboratory is a fully equipped one with standard biotechnology and molecular biology research. Several extra-mural grants of different faculty members of Division of Plant Biology have enriched the repository of this laboratory.

Faculty Member

Dr. Gaurab Gangopadhyay (Scientist-in-charge)

Staff Members

Mr. Amit Kumar Ghosh (Assistant Registrar-I) Superannuated on 31.12.2018; Mr. Pulak Kr Roy (Technical Officer I); Mr Asis Kumar Dalal (Technical Officer I); Sk Inal Ali (Field Assistant); Mr Mahesh Dasgupta (Field Assistant); Mr Laxmi Kanta Pradhan (Field Assistant); Mr Bhanu Kisku (Field Assistant)

Research personnel (project)

Dr. Sambit Datta (RA)

Madhyamgram Experimental Farm

Madhyamgram Experimental Farm (MEF) organized the third "Hands-on-Training" programme on "Basic and Applied Physical and Biological Sciences for the High School Students" during December 18-20, 2018. Thirty-five students of Class X-XII along with their teachers from six schools in the vicinity of MEF attended this programme. They performed experiments on Microbiology, Physics of Nanomaterials and Plant Biotechnology. They learnt the techniques to use of animals in drug development/translational medical research and observed a 3D view of the molecular world. The students also attended lectures on Crop improvement, Atmospheric Investigations over Antarctica, 'DNA origami' and 'Fun with Mathematics'.

Madhyamgram Experimental Farm

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 organizations 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 45067 as on 31.03.2019 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 e-journals can be accessed from 1997 onwards. Library is also having very old rich print collection of important science journals.

Staff Members: Dr. Arun Kumar Chakraborty (Librarian), Ms. Ananya Raha, Ms. Sumita Dey, Ms. Tanusri Bhattacharya, Mr. Mrityunjoy Jogsharma (superannuated on 30.04.2018), Dr. (Ms.) Banhisikha Choudhury (superannuated on 31.05.2018), Mr. Dinanath Das (superannuated on 30.09.2018)

Activities

Collection Development:

- Books
- Bound Volumes of Journals
- Theses
- Online Journals subscribed
- Online journals through National Knowledge Resource Consortia (NKRC)

- Scientific Software(s)
- Back Volume Journals (online)
- Sir J.C. Bose Collection
- Reports, Newsletters, Annual Reports of other Institute(s),
- Publication of Bose Institute etc.

1. 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. Library uses open sources software KOHA for Web-OPAC and D-Space for IDR. For access management library maintains servers.

2. Resources of Bose Institute Library

Resources of BI Library can be accessed from Bose Institute Library Portal (www.jcbose.ac.in/library).

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, Cambridge Journals 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, Springerlink, Landes Bioscience, Microbiology Research Foundations, National Academy of Sciences, Physical Society of Japan, Portland Press, 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. Back Volume Journals:

Elsevier Backfiles on Science Direct	Wiley Blackwell Journal Back files
1. Biochemistry, Genetics and Molecular Biology	1. Biotechnology, Biochemistry and Biophysics
2. High Energy Physics	2. Physics
3. Cell Press	3. Immunology
	4. Microbiology

C. E-Books Collection

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

D. Publication Support:

Biomed Central (BMC) Article Processing

E. Databases

Library also subscribed to different databases such as :

- SCOPUS the largest abstract and citation database of research literature and quality web sources of Elsevier.
- Clarivate Analytics Web of Science Core Collection: Citation database in the Sciences, Social sciences, Arts, and Humanities.
- SciFinder®, a research discovery tool that allows to explore the comprehensive and authoritative CAS databases

F. Scientific Softwares services by Library:

Sl. No.	Software(s)	Publishers
1.	ENDNOTE X8 Multi User Download-Research Software	Clarivate Analytics
2.	Tair Site (tier-4)	Phoenix Bioinformatics Corporation
3.	iThenticate : Plagiarism Checking Software	Turnitin
4.	Grammarly@edu writing support Suite	Bridge People Technology Solutions Pvt. Ltd

Library

Sl. No.	Software(s)	Publishers
5.	MatInspector and MatBase	Intrexon Bioinformatics
6.	Pathway Studio-Plant	Elsevier
7.	IPA(Ingenuity® Pathway Analysis) Software	QIAGEN India Pvt. Ltd.
8.	TRANSFAC Online	GeneXplain
9.	HGMD	QIAGEN India Pvt. Ltd.

G. Resources through NKRC (http://nkrc.niscair.res.in/indexpage.php):

Library has joined with the National Knowledge Resource Consortia (NKRC) since 2008 which is joint consortia of CSIR and DST Institutes for accessing online resources. Through this consortia faculty members/scholars of this institute can access more than 5000+ online resources, SCIFINDER of 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.

H. New Addition(s) in 2018-2019:

- Book(s) added in 2018-2019 : 170 nos.
- Thesis added : 39 nos.

3. Services :

The library is open to faculty member and scholars for reading and consultation during institute working hours.

Reader's Service

Faculty members / scholars can access (24x7) E-resources from any of the seven campuses of Bose

Faculty members also can access E-resources from off campuses/ home access (24x7).

Faculty/Scholars from different Universities/Institutes in and around Kolkata can access BI resources.

Lending Service

Faculty members, scholars, students, staff can access library resources during Institute working hours.

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.

Library

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. Library provides article request service to BI faculty/scholars. Library also provide article services to faculty members/scholars across India.
Institutional Membership	The library is member of various National and International organization(s) (i) Biomed Central (BMC), (ii) Public Library of Science (PLoS), (iii) International Federation of Library Associations and Institutions (IFLA), (iv) Indian Association Of Special Libraries And Information Centres (IASLIC), (v) 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 its users of the Institute and outside users also.
Plagiarism check Service	Library provides plagiarism checking service of articles, book chapters, MSc. PHD. Dissertations, Thesis for faculty members and research scholars.
Bibliographic & Full text Search Services	Library provides Bibliographic and full text search services from various databases like Web of Science, Scopus, SciFinder, PubMed etc. for its users and also outside users.

Library

Scientific Software Services	Library provides access to various Scientific Softwares (mentioned above in F.) from its different campus.
WEB-OPAC	Online access to Library holdings data is available through WEB-OPAC (Online Public Access Catalouge). Users have the facility to browse and search the Library database and view the status of a document.
Institutional Repository	Library has created Institutional Repository using Dspace Software which is an open Access initiative. It is a digital repository of Thesis Collections of the Institute, Publication of Faculty members, Annual Reports of the Institute, J C Bose Collection, D M Bose Collection, Transactions etc.
New Initiatives	Library has become the participating library in the NDL (National Digital Library) project, initiated by MHRD, Govt of India. Library has also taken initiative for implementing RFID (radio frequency identification) tagging for its collection.

Further Academic Activities

Library also provides training to library school students like Internship programme to LIS school students, training to Library professionals, advising different libraries for developing modern automated library, organizing training programmes / workshops for LIS professionals etc.

Publication(s)

Chakraborty A K (2018) Role of Public Libraries as Community Information Hub/ ESHONA: Journal of Gurudas College,Issue July 2017- June 2018 ISSN 23490985

Conference / Symposia / Workshops

Dr. Arun Kumar Chakraborty (Librarian)

(Idelivered a special lecture as a visiting scientist at DRTC, Indian Statistical Institute Bangalore on 25th-29th March., 2019. (ii)Delivered a lecture as Guest of Honour in the inaugural session of the 'National Seminar on Libraries for all' organized by the DLIS, RBU, West Bengal on 7th& 8th March 2019. (iii) Delivered invited lecture in one-day State Level seminar at 'Sudhiranjan Lahiri Mahavidyalaya' on 6th Mar, 2019. (iv)Delivered invited lecture on International Conference on 'Future of Libraries' at IIM Bangalore on 26th -28th Feb., 2019. (v) Invited 'INDKOHA 2019' as Chief Guest on 23rd Feb.-24th Feb., 2019. (vi) Delivered invited lecture on national seminar on 'Public Library and digital divide: Opportunities and challenges' at Sambalpur Public Library on 22nd -23rd February, 2019. (vii) Invited to chair 'Sixth International Conference of Asian Special Libraries

(ICoASL 2019)' on 14th-16th February held in Delhi. (viii) Chaired a session at Institute of Public Growth, Delhi on 14.02.2019. (ix) Invited as a Guest of Honour in the Inaugural Ceremony of 43rd International Book Fair, 2019 Kolkata. (x) Invited LINE, 2018 at Kalyani University as a guest of Honour at 29th Jan., 2019. (xi) Invited on 5th Tangra Science Fair as a Guest of Honour at 25th Jan., 2019. (x) Invited to deliver a special lecture on 'E-resources issue' at RBU, DLIS, Kolkata on 14th Jan., 2019. (xi) Invited to deliver lecture as a resource person on 24th September, 2018 at UGC Sponsored Refresher Course in Library and Information Science at LIS, Calcutta University, Kolkata

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 like gradient mixtures, gel tray etc. 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.

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 18-19

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

Staff Members : Mr. Raju Chandra Paul ,Workshop Superintendent.

Main Campus: Mr. Bholanath Saren, Mr. Abdul Rahaman Molla, Mr. Sk. Md. Farruck, Mr W.D. Rozario (superannuated on 31.12.2018), Mr. Rajkumar Das, Mr. Pranab Banerjee, Mr. Brahmdeo Prasad, Mr. Subrata Basak, Mr. Sanjoy Santra, Mr. Kodan Das.

Centenary Campus: Mr. Ashit Banerjee (superannuated on 30.06.2018), Mr. Baidya Nath Murm.

Outreach & Man Power Development

Dissemination of knowledge has been an integral part of the charter of Bose Institute as proclaimed by J. C. Bose in his foundation speech in 1917. In recent years many outreach programmes has been undertaken to acquaint the school children 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 school students of Darjeeling is held regularly at the Darjeeling campus of Bose Institute. The faculties working at Darjeeling campus interact with the school students in regular intervals. Moreover, school students participating in the children's science congress interact with our faculties for their project work. Bose Institute also collaborates with other organizations for organizing science camps for school students in and around Kolkata. Hands-on training camps has also been organized for the school teachers of North-Eastern states as well as Darjeeling to help them in integrating the experiment based teaching with their regular class room teaching.

In order to extend the benefit of the advancement of our knowledge to rural sector Bose Institute has initiated a rural biotechnology programme. Under this programme the people from rural sector are given training for Mushroom cultivation, Pisciculture, Sericulture and Apiculture.

Outreach & Man Power Dev.

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 2018: April 30 – May 12, 2018.

The 12th North-East Students' Summer Training on BAsic SciEnces (NESST-BASE) was held at Darjeeling during April 30 – May 12, 2018. This year, 24 students from north-east states as well as Sikkim and Darjeeling, along with one science teacher from each place, participated in this programme. The state authorities selected the students. These students were given hands-on training on physical, chemical and biological sciences. There were also sessions with the aim to introduce the students with the fun of mathematics. This year popular lectures were delivered by Prof. Partha Ghose, Honorary Scientist, National Academy of Sciences, India on "Who`s afraid of

Stephen Hawking" and Prof .Vasant Shinde , Vice-Chancellor, Deccan College, Post-Graduate and Research Institute Deemed University on "Archaeology: An Important Science for History Writing"

(b) Rural Biotechnology programmes:

Scheduled Tribe Specific Rural Biotechnology Programme has started its journey in the year 2014 which is financed by Department of Science & Technology, Government of India for the development of Socio-economic status of Scheduled Tribe community people throughout the West Bengal. The major objectives of this programme is socio-economic upliftment, generation of awareness, empowerment of womenof the Scheduled Tribe people in West Bengal through various programmes viz Sericulture, Agriculture, Orchard, Mushroom cultivation, Vermicompost production, Fishery, Apiculture, Piggery, Food Processing, Goat rearing, Rainwater harvesting for agriculture as well as drinking purpose, Country chicken rearing, Betel Leaf Cultivation, Crab Culture etc.

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.

Staff Members : Shri Soumya Shankha Biswas, Shri Prabir Halder.

On-going Projects as on 31.03.2019

	FUNDING AUTHORITY	FINANCIAL YEAR OF COMMENC-EMENT	FINANCIAL YEAR OF TERMINATION	DATE OF COMMENC-EMENT	DATE OF TERMINA-TION	PRINCIPAL INVESTIGATOR	TITLE OF THE PROJECTS	GRANT SANCTIONED
1171	CSIR	2014-15	2018-19	1-Oct-14	30-Sep-18	Dr. Pallob Kundu	Exploring membrane-associated NAC-transcription factors (NAC MTFs) in tomato to apprehend membrane mediated signaling during pathogenesis	2,538,600
1177	CSIR	2014-15	2018-19	1-Jan-15	31-Dec-18	Dr. Abhrajyoti Ghosh	Investigation of the archaeal diversity and activity in Sundarbans mangrove sediment, India	3,793,800
1232	CSIR	2015-16	2018-19	1-Jan-16	31-Dec-18	Dr. Anup Kumar Misra	Synthesis of oligosaccharide fragments corresponding to *Salmonella* strains and their use in the preparation of glycoconjugate derivatives	900,000
1249	CSIR	2016-17	2019-20	1-Jun-16	31-May-19	Prof. Manju Roy	Assessment of the anti-cancer effect of Methylglyoxal in combination with conventional anticancer drugs at Metronomic doses with special reference to cancer stem cells	2,443,800
1329	CSIR	2017-18	2020-21	1-Jul-17	30-Jun-20	Dr. Anirban Bhunia	Structural insight and Dynamical properties of Alpha synuclein fibrillation in the context of Mitochondrial membrane or Biological membrances : Pathological role in synaptic transmission Aggregation property and cellular toxicity	2,443,800
1336	CSIR	2017-18	2020-21	10-Jul-17	31-Jul-20	Prof. Subrata Majumdar	Crucial role of transcription factor-EB (TFEB) in regulating differential antigen presentation and cross presentation during Leishmania donovani infection	2,593,800

1338	CSIR	2017-18	2020-21	1-Aug-17	31-Jul-20	Prof. Samir Ranjan Sikdar	Proteome analysis during Lipaphis erysimi - Rorippa indica incompatible interaction to identify putative proteins responsible for aphid tolerance and their interacting partners	1,500,000
1358	CSIR	2017-18	2020-21	25-Jul-17	31-Jul-20	Prof. Swati Gupta Bhattacharyya	Deciphering the in-planta secretome of Rhizoctonia solani AG1-1A during infection of rice	2,893,800
381	**DBT**		2019-20		**31-Mar-20**	**Prof. Pinakpani Chakrabarti**	"National Facility on **Interactive Graphics Computer System** for Biomolecular Modeling, Molecular Dynamics & Structures at Bose Institute, Kolkata"	
775(A)	DBT	2002-03	2019-20		31-Mar-20	Prof. Pinakpani Chakrabarti	"Centre of Excellence(COE) at Bose Institute"	2,92,50,000
1033	DBT	2011-12	2017-18	9-Jan-12	8-Jan-18	Prof. Joyoti Basu	Sys TB : A Network Program for Resolving the Intracellular Dynamics of Host Pathogen Interaction in TB infection	2,20,24,800
1172	DBT	2014-15	2018-19	12-Nov-14	11-May-18	Dr. Kaushik Biswas	Understanding the role of tumor derived glycosphingolipids in carcinogenesis : An *invivo* approach	4,306,000
1173	DBT	2014-15	2018-19	1-Nov-14	30-Apr-18	Dr. Atin Kumar Mandal	Raf1 quality control and development of pathophysiological conditions	4,879,000
1180	DBT	2014-15	2017-18	24-Mar-15	23-Mar-18	Dr. N. Mandal	Identification and characterization of micro RNAs (miRNAs) in *Penaeus monodon*	4,406,200
1192	DBT	2014-15	2018-19	30-Jan-15	29-Nov-18	Prof. Subrata Majumdar	TLR2-dependent engagement of the host cell kinases and phosphatases that dictate disease progression or resolution	4,540,000
1257	DBT	2015-16	2018-19	7-Jul-15	6-Jul-18	Dr. Sudipto Saha	Identifying Systems-level Cellular Networks Involved in Neurotropic Flavi Virus-Host Interaction	120,000
1273	DBT	2016-17	2019-20	23-Aug-16	22-Aug-19	Prof. Swati Gupta Bhattacharyya	Development of Molecular Diganostics and Immunotherapeutic Vaccines for Prawn and Brinjal Allergy	4,713,600

1285	DBT	2016-17	2019-20	19-Oct-16	18-Oct-19	Prof. Debabrata Basu	Development of High yielding, Non lodging and Biotic resistant Varieties of Black Scented Rice of Manipur and Joha Rice of Assam through Biotechnological Intervention	735,000
1305	DBT	2016-17	2019-20	19-Jan-17	18-Jan-20	Prof. Tapan K. Dutta	Hydrogenogenic carbon monoxide conversion under mesophilic condition using anaerobic granular sludge biomass for biodesulphurization	2,574,000
1312	DBT	2016-17	2020-21	9-Jan-17	8-Jan-21	Director, Bose Institute	Multi-dimensional Reserch to Enable Systems Medicine: Acceleration using a Cluster Approach' at Kalyani, West Bengal	140,532,000
1348	DBT	2017-18	2020-21	13-Jul-17	12-Jul-20	Prof. Manikuntala Kundu	Transcriptional regulator RegX3-dependent modulation of the macrophage immune response by Mycobacterium tuberculosis	6,184,000
1387	DBT	2017-18	2020-21	30-Jan-18	29-Jan-21	Prof. Mahadeb Pal	Understand molecular mechanism of action of a protein chaperone inducer azadiradione and its therapeutic development for Parkinson's disease treatment	3,602,000
1429	DBT	2018-19	2021-22	16-Jul-18	15-Jul-21	Dr. Pallob Kundu	Developing an optimized toolkit for induicible genome editing and regulation of gene expression in tomato plant: implicaitons in adjusting complex traits via synthetic biology approach	7,806,800
1441	DBT	2018-19	2021-22	24-Sep-18	23-Sep-21	Prof. Gaurisankar Sa	Development of delivery system for miR-325-3p for immunotherapy of cancer	7,929,800
1443	DBT	2017-18	2020-21	23-Mar-18	22-Mar-21	Prof. Siddhartha Roy	Solid tumor targeting using homing peptides and plasmonic photothermal technique	4,684,800
1199	DBT-NOW	2015-16	2018-19	2-Sep-15	19-Aug-20	Prof. A. N. Lahiri Majumder	Unraveling the role of PLC in plant drought and heat stress tolerance: Exploring the potential of PI metabolism to improve crop yield	12,687,600
1201	DBT-RGCB	2015-16	2019-20	29-Jul-15	27-May-19	Dr. Kaushik Biswas	Role of c-Jun N-Terminal Kinase (JNK) in tumor derived soluble factor mediated T cell apoptosis	2,490,000

1185	DBT-WB	2015-16	2017-18	1-Apr-15	31-Mar-18	Dr. Abhrajyoti Ghosh	Assessment of Plant Growth Promoting Bacteria in the Mangrove Rhizosphere and evolution of Plant Growth Promotion Activity on Rice (Oryza sativa)	2,595,520
1277	DBT-WB	2016-17	2019-20	31-Aug-16	30-Aug-19	Prof. Amita Pal	Genome wide transcriptome analysis to develop strategies for quality improvement of blackgram	3,047,320
1398	DBT-WB	2018-19	2021-22	15-May-18	14-May-21	Dr. Gaurab Gangopadhyay	Development of Transgenic Pineapple Over-expressing AcSERK to Combat Fungal Pathogens	1,999,645
1406	DBT-WB	2018-19	2021-22	2-Jul-18	1-Jul-21	Dr. Shubho Chaudhuri	Investigating the role of Trithorax factor ULTRAPETALA1 in salt stress response in rice	4,331,840
1440	DBT-WB	2018-19	2021-22	28-Aug-18	27-Aug-21	Prof. Gautam Basu	The significance of feedback loop between ZEB1 and PRMT in Fbroblast growth factore (FGF)-mediated epithelial-mesenchymal transition in Breast Cancer	3,030,000
1154	DST	2014-15	2019-20	10-Jul-14	31-Mar-20	Dr. Supriya Das	ALICE - A Large Ion Collider Experiment (ALICE) upgrade, operation and utilization	60,500,000
1223	DST	2015-16	2018-19	3-Dec-15	2-Dec-18	Prof. Siddhartha Roy	Development of nano-particle based directed systems for peptide therapeutics	14,041,600
1313	DST	2017-18	2020-21	20-Mar-17	19-Mar-20	Prof. P.C.Sen	Targeting onco-miRNAs with a novel oleic acid-pluoronic stabilized porous TiO2 nanoparticle for specific synergistic delivery of small molecule combination to combat triple negative breast cancer	4,291,584
1457	DST	2018-19	2020-21	28-Mar-19	27-Mar-21	Prof. Sanjay K. Ghosh	Development of a cost effective and portable electro-optical system for effective investigation of residual ambient gases using spark emission spectrometry towards the estimation of atmospheric gases compostiton w.r.t. height using high flying drones	2,437,600
1399	DST(SPLICE-Climate Change Programme)	2017-18	2020-21	22-Mar-18	21-Mar-21	Dr. Abhijit Chatterjee	Understanding the Role of Local and Transported Biogenic and Anthropogenic Aerosols on Microphysical and Chemical Properites of Low Level Clouds Over Eastern Himalaya, India	7,408,800

1386	DST-Technology Mission Division (INDO-UK)	2017-18	2020-21	26-Feb-18	25-Feb-21	Prof. Tapan K. Dutta	The development and implementation of sensors and treatment technologies for freshwater systems in India	34,227,700
1184	ICMR	2014-15	2018-19	1-Mar-15	31-Aug-18	Prof. Swati Gupta Bhattacharyya	Systematic discovery of biomarkers of asthma caused by common environmental allergens using human plasma proteomics, cytokine profiling and network biology - aystem approach to drug discovery	1,693,900
1307	ICMR	2016-17	2019-20	1-Mar-17	29-Feb-20	Dr. Sudipto Saha	Systematic identification of regulatory networks in pluripotent cells integrating coding and noncoding word	3,300,000
1311	ICMR	2016-17	2019-20	1-Mar-17	29-Feb-20	Dr. Zhumur Ghosh	Epigenetic Alterations Inducing Oncogenicity in Stem Cell Derivatives	2,189,200
1293	IFCC	2016-17	2022-23	1-Aug-16	31-Jul-22	Prof. Sanjay K. Ghosh	CBM MUCH	288,040,000
1097	IITM(MOES)	2018-19	2021-22	13-Sep-18	12-Sep-21	Dr. Abhijit Chatterjee	Study on Biosphere-Atmosphere Exchange of Carbon Dioxide, Water Vapour and Energy in a High Altitude Forest Canopy at Eastern Himalaya	2,508,000
1340	Indo-Swedish	2017-18	2019-20	20-Jun-17	19-Jun-19	Dr. Anirban Bhunia	Antimicrobial peptides against crop disease	3,139,000
1200	ISRO	2015-16	2018-19	6-Aug-15	5-Aug-18	Dr. Dhruba Gupta	Astrophysical S-factor from nuclear reactions with a rare isotope beam ^{7}Be	3,850,000
1362	MoEFCC	2016-17	2022-23	29-Mar-17	28-Jun-22	Dr. Abhijit Chatterjee	National Carbonaceous Aerosols Programme (NCAP) WGIII: Carbonaceous Aerosols Emmissions, Source appointment and Climate effects	10,608,000
1224	MOES	2015-16	2017-18	2-Jan-16	1-Jan-18	Dr. Wriddhiman Ghosh	Vertical profilling of the sedimentary microbiome of the Arabia sea OMZ with special reference to carbon and sulfur cycles	1,100,000
1218	SERB	2015-16	2018-19	18-Dec-15	17-Dec-18	Prof. N. Mandal	Molecular characterization of developed DNA markers linked to disease resistance/susceptibility in giant black tiger shrimp, *Penaeus monodon*	4,866,800
1222	SERB	2015-16	2018-19	28-Oct-15	27-Oct-18	Prof. Gaurisankar Sa	R-325 : A distinct micro-RNA that controls T-regulatory cell development and function	5,168,000

1228	SERB	2015-16	2019-20	20-Jan-16	14-Jul-19	Prof. Siddhartha Roy	Development of Synthetic Transcription Factors against pluripotency to Target Cancer Stem Cells	5,665,099
1244	SERB	2015-16	2018-19	19-Mar-16	18-Mar-19	Prof. Joyoti Basu	Evaluating the sensor kinase MtrB of Mycobacterium tuberculosis as a regulator of bacterial physiological responses, and as a potential target for therapy	6,011,200
1248	SERB	2015-16	2018-19	9-Oct-15	8-Oct-18	Prof. Anup Kumar Misra	Synthesis of the polysaccharide fragments of Streptococcus pneumoniae strains for the preparation of glycoconjugate derivatives	1,690,000
1269	SERB	2016-17	2019-20	18-Jul-16	28-Dec-19	Dr. Somshubhra Bandyopadhyay	Studies on quantum entanglement as a resource for quantum information processing	1,789,344
1282	SERB	2016-17	2019-20	30-Aug-16	29-Aug-19	Dr. Subhrangsu Chatterjee	Understanding the role of G-quadruplex structures in BC1-2, KRAS and c-MYC promoters in the development of cancer	4,694,750
1303	SERB	2016-17	2019-20	10-Mar-17	9-Mar-20	Dr. Zhumur Ghosh	Elucidating the GWAS-Associated Genetic Variants within lncRNA candidate loci: Role in Cancer	4,518,800
1306	SERB	2016-17	2019-20	21-Mar-17	20-Mar-20	Dr. Atin Kumar Mandal	Role of co-chaperones in triage decision of Hsp70	3,943,000
1314	SERB	2016-17	2019-20	21-Mar-17	20-Mar-20	Dr. Kaushik Biswas	A novel role of ganglioside GM2 in the regulation of the Hippo signaling pathway in tumorigenesis	4,416,183
1407	SERB	2017-18	2020-21	16-Mar-18	15-Mar-21	Dr. Anupama Ghosh	Evaluation of secreted proteases of Ustilago maydis as potential effector proteins	2,553,394
1428	SERB	2018-19	2021-22	24-Jul-18	23-Jul-21	Dr. Shubho Chaudhuri	Investigating the role of Arabidopsis ARID-HMG protein, AtHMGB15, in the pollen development process	4,629,744
1434	SERB	2018-19	2021-22	9-Aug-18	8-Aug-21	Dr. Zhumur Ghosh	SERB Women Excellence Award to Dr. Zhumur Ghosh, BIC "LncRNA target connectivity to Small Molecules: Implication in Cancer Therapy"	1,800,000
1439	SERB	2018-19	2021-22	15-Sep-18	14-Sep-21	Dr. Achintya Singha	Fabrication of Infreared Photo-detector based on 2D systems and Tuning the Detection Windows by coupling with Nanostructures	5,033,714

1442	SERB	2018-19	2021-22	11-Oct-18	10-Oct-21	Dr. Jayanta Mukhopadhyay	Evaluating the role and mechanism of function of delta factor of Bacillus subtilis	3,069,000
1463	SERB	2018-19	2021-22	26-Mar-19	25-Mar-22	Dr. Abhrajyoti Ghosh	Response of B. aryabhattai AB211 to maize root exudates: insights from transcriptome analysis	3,868,803
795	SERB(DST)	2007-08	2022-23	3-May-07	2-May-22	Prof. Pinakpani Chakrabarti	Award of J.C. Bose Fellowship to Prof. Pinakpani Chakrabarti	40,00,000
1198	SERB(DST)	2006-07	2021-22	26-Mar-07	31-Mar-22	Prof. Siddhartha Roy	Award of J.C. Bose Fellowship to Prof. Siddhartha Roy	9000000 (FOR LAST 5YEARS)
1139	SERB(DST)	2014-15	2017-18	8-Jul-14	7-Jan-18	Prof. D.N.Sengupta	Functional Analysis of the DNA polymerase lambda gene and the protein from Indica Rice Cultivars	3,789,600
1191	SERB(DST)	2015-16	2018-19	3-Jun-15	2-Dec-18	Prof. Manikuntala Kundu	Regulation of the mycobacterial stress response by the two-component system SenX3-RegX3 in Mycobacterium tuberculosis	5,660,000
1278	SERB(DST)	2016-17	2019-20	12-Sep-16	11-Sep-19	Dr. Shubhro Ghosh Dastidar	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	3,080,000
1281	SERB(DST)	2016-17	2019-20	25-Oct-16	24-Oct-19	Prof. Parames C. Sil	Targeting the mrRNA axis with a synthetic small molecule, Nifetepimine to restrict migration of triple negative breast cancer cells	4,312,800
1327	SERB(DST)	2016-17	2019-20	23-Mar-17	22-Mar-20	Dr. Wriddhiman Ghosh	Quest for the biophysical basis of habitability of dydrothermal vent ecosystems	3,584,420
1375	SERB(DST)	2016-17	2019-20	1-Apr-17	31-Mar-22	Prof. Joyoti Basu	Award of J.C. Bose Fellowship to Prof. Joyoti Basu	5,400,000
1390	SERB(DST)	2017-18	2020-21	5-Mar-18	4-Mar-21	Prof. Tanya Das	Role of Cancer Stem Cells in Tumor Neo-Angiogenesis : A mechanistic study	4,876,800
1396	SERB(DST)	2017-18	2020-21	21-Mar-18	20-Mar-21	Prof. Sujoy K. Das Gupta	Phage inspired antibiotics for mycobacteria	3,896,800

1401	SERB(DST)	2017-18	2020-21	15-Mar-18	14-Mar-21	Prof. Parames C. Sil	Nanoparticle-mediated co-delivery of chemotherapeutic drugs and genes for synergistic cancer treatment	2,866,800
1042	SERC-IRHPA-II	2012-13	2018-19	1-Aug-12	30-Sep-19	Prof. Sanjay K. Ghosh	Study of cosmic ray interactions and cosmic ray aerosol cloud connection in the context of regional climate change	16,26,16,000
1301	WWF	2016-17	2019-20	1-Dec-16	31-Jul-19	Prof. Swati Gupta Bhattacharyya	Study to understand the pollination ecology as well as applicability of placing apiary boxes in the forested area of Sundarbans	3,000,000

Research Papers/Books Published by Faculty Members & Senior Scientists

BIOCHEMISTRY

1	Bhattacharyya A, Haldar A, Bhattacharyya M, Ghosh A	Anthropogenic influence shapes the distribution of antibiotic resistant bacteria (ARB) in the sediment of Sundarban estuary in India	Sci Total Environ	2019
2	Roy M, Gupta S, Patranabis S, Ghosh A	The oligomeric plasticity of Hsp20 of Sulfolobus acidocaldarius protects environment-induced protein aggregation and membrane destabilization	Total Environ	2019
3	Roy D, Pramanik A, Banerjee S, Ghosh A, Chattopadhyay D, Bhattacharyya M	Spatio-temporal variability and source identification for metal contamination in the river sediment of Indian Sundarbans, a world heritage site	Environmental Science and Pollution Research	2018
4	Datta S P, Jana K, Mandal A, Ganguly S. and Sarkar S	Multiple paralogues of -SNAP in Giardia lamblia exhibit independent subcellular localization and redistribution during encystation and stress	Parasit Vectors	2018
5	Datta S P, Jana A, Saha N, Bhattacharjee C, and Sarkar S	Phosphoinositides and Rab GTPases: identity markers of vesicular trafficking	Advances in Medico-Veterinary Parasitology: An Indian Perspectiv, Editors:Arun K. Yadav, Veena Tandon and S. L. Hoti; Panima Publishing Corporation, New Delhi	2018
6	Seal S, Polley S, Sau S.	A staphylococcal cyclophilin carries a single domain and unfolds via the formation of an intermediate that preserves cyclosporin A binding activity	PLoS One	2019
7	Biswas A, Ghosh S, Sinha D, Dutta A, Seal S, Bagchi A, Sau S	Dimerization ability, denaturation mechanism, and the stability of a staphylococcal phage repressor and its two domains	Int. J. Biol Macromol	2018
8	Mandal S, Ghosh S, Sinha D, Seal S, Mahapa A, Polley S, Saha D, Sau K, Bagchi A, Sau S	Alanine substitution mutations in the DNA binding region of a global staphylococcal virulence regulator affect its structure, function, and stability	Int .J. Biol Macromol	2018
9	Sinha D, Mondal R, Mahapa A, Sau K, Chattopadhyaya R, Sau S	A staphylococcal anti-sigma factor possesses a single-domain, carries different denaturant-sensitive regions and unfolds via two intermediates	PLoS One	2018
10	Mahapa A, Mandal S, Sinha D, Sau S, Sau K	Determining the Roles of a Conserved -Helix in a Global Virulence Regulator from Staphylococcus aureus	Protein J	2018

Research Papers / Books Published

BIOINFORMATICS

11	Chakraborty J, Priya P, Dastidar SG, Das S	Physical interaction between nuclear accumulated CC-NB-ARC-LRR protein and WRKY64 promotes EDS1 dependent Fusarium wilt resistance in chickpea	Plant Sci.	2018
12	Maity A, Majumdar S, Ghosh Dastidar S	Flexibility enables to discriminate between ligands: Lessons from structural ensembles of Bcl-xl and Mcl-1	Comput Biol Chem	2018
13	Sarkar D, Jana T, Saha S	LMDIPred: A web-server for prediction of linear peptide sequences binding to SH3, WW and PDZ domains	PLoS One	2018
14	Majumdar S, Ghosh A, Saha S	Modulating Interleukins and their Receptors Interactions with Small Chemicals Using In Silico Approach for Asthma	Curr Top Med Chem.	2018
15	Chakravorty D, Banerjee K and Saha S	Integrative Omics for Interactomes	Synthetic Biology, S. Singh (ed.), Springer Nature Singapore Pte Ltd	2018
16	Victor MP, Acharya D, Begum T, Ghosh T C	The optimization of mRN expression level by its intrinsic properties-Insights from codon usage pattern and structural stability of mRNA	Genomics	2018
17	Sen K, Bhattacharyya D, Sarkar A, Das J, Maji N, Basu M, Ghosh Z, Ghosh T C	Exploring the major cross-talking edges of competitive endogenous RNA networks in human Chronic and Acute Myeloid Leukemia	Biochim Biophys Acta Gen Subj.	2018
18	Mukherjee D, Saha D, Acharya D, Mukherjee A, Chakraborty S, Ghosh T C	The role of introns in the conservation of the metabolic genes of Arabidopsis thaliana.	Genomics	2018
19	Biswas K, Acharya D, Podder S, Ghosh TC	Evolutionary rate heterogeneity between multi- and single-interface hubs across human housekeeping and tissue-specific protein interaction network: Insights from proteins' and its partners' properties	Genomics	2018
20	Mondal S, Maji R K, Ghosh Z, Khatua S	ParStream-seq: An improved method of handling next generation sequence data	Genomics	2018
21	Chakraborty S and Ghosh Z	A systemic insight into astrocytoma biology across different grades	J Cell Physiol	2018
22	Maji R K, Khatua S, Ghosh Z	A supervised ensemble approach for sensitive microRNA target prediction	Trans Comput Biol Bioinform	2018
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75	Huo Chang-Xin, Dhara Debashis, Baliban Scott M, Nick Setare Tahmasebi, Tan Zibin, Simon Raphael, Misra Anup Kumar and Huang Xuefei	Synthetic and immunological studies of *Salmonella* Enteritidis O-antigen tetrasaccharides as potential anti-*Salmonella* vaccines	Chem Commun.	2019

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89	Banerjee A, Mahata B, Dhir A, Mandal T K, Biswas K	Elevated histone H3 acetylation and loss of the Sp1-HDAC1 complex de-repress the GM2-synthase gene in renal cell carcinoma	J. Biol Chem.	2019
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92	Barun Mahata and Kaushik Biswas	Generation of stable knockout mammalian cells by TALEN-mediated locus specific gene editing	Methods Mol Biol.	2018
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98	Paul S, Ghosh S, Mandal, S, Sau S and Pal	MNRF2 transcriptionally activates the heat shock factor 1 promoter under oxidative stress and affects survival and migration potential of MCF7 cells	J Biol Chem	2018
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138	S. Acharya et al. (ALICE Collaboration)	Transverse momentum spectra and nuclear modification factors of charged particles in pp, p-Pb and Pb-Pb collisions at the LHC	JHEP 1811	2018
139	S. Acharya et al. (ALICE Collaboration)	Medium modification of the shape of small-radius jets in central Pb-Pb collisions at qrt(sNN) = 2.76TeV	JHEP 10	2018
140	S. Acharya et al. (ALICE Collaboration)	Neutral pion and η meson production at mid-rapidity in Pb-Pb collisions at qrt(sNN) = 2.76 TeV	Phys. Rev. C 98	2018
141	S. Acharya et al. (ALICE Collaboration)	Anisotropic flow of identified particles in Pb-Pb collisions at sqrt(sNN) = 5.02 TeV;	JHEP09	2018
142	S. Acharya et al. (ALICE Collaboration)	Anisotropic flow in Xe-Xe collisions at sqrt(sNN) = 5.44 TeV	Phys. Lett. B 784	2018
143	S. Acharya et al. (ALICE Collaboration)	Longitudinal asymmetry and its effect on pseudorapidity distributions in Pb-Pb collisions at sqrt(sNN) = 2.76 TeV	Phys. Lett. B 781	2018
144	S. Acharya et al. (ALICE Collaboration)	Constraints on jet quenching in p-Pb collisions at sqrt(sNN) = 5.02 TeV measured by the event-activity dependence of semi-inclusive hadron-jet distributions	Phys. Lett. B 783	2018
145	Halder Saronath, Banik Manik, Agrawal Sristy, Bandyopadhyay Somshubhro	Strong quantum nonlocality without entanglement	Phys. Rev. Lett.	2019
146	Zuppardo Margherita, Ray Ganardi, Miller Marek, Bandyopadhyay Somshubhro	Paterek Tomasz Entanglement gain in measurements with unknown results	Phys. Rev.A 99	2019
147	Grewal RK, Sinha S, and Roy S	Topologically inspired walks on randomly connected landscapes with correlated fitness	Frontiers in Physics	2018
148	Sinha S, Ghosh S and Roy S	A pedestrian review of games on structured populations.	International Journal of Advances in Engineering Sciences and Applied Mathematics	2019
149	Sinha S, Grewal RK and Roy S	Modeling bacteria-phage interactions and implications for phage therapy	Advances in Applied Microbiology	2018
150	Das S.	Particle identification studies with a full-size 4-GEM prototype for the ALICE TPC upgrade	Nucl. Inst. Meth. A903	2018
151	Das S.	Longitudinal asymmetry and its effect on pseudorapidity distributions in Pb-Pb collisions at \sqrt{s_NN} = 2.76 TeV	Phys. Lett. B 781	2018

Research Papers / Books Published

152	Das S.	First measurement of Ξ^0_c production in pp collisions at \sqrt } = 7 TeV	Phys. Lett. B 781	2018
153	Das S.	Λ^+_c production in pp collisions at \sqrt }=7 TeV and in p-Pb collisions at \sqrt _NN}=5.02 TeV	JHEP 04	2018
154	Das S.	Prompt and non-prompt J/ψ production and nuclear modification at mid-rapidity in p-Pb collisions at \sqrt{s_ }=5.02 TeV	Eur. Phys. J. C 78	2018
155	Das S.	Constraints on jet quenching in p-Pb collisions at \sqrt{ N}= 5.02 TeV measured by the event-activity dependence of semi-inclusive hadron-jet distributions	Phys. Lett. B 783	2018
156	Das S.	Measurement of the inclusive J/ψ polarization at forward rapidity in pp collisions at \sqrt{ } =8 TeV	Eur. Phys. J. C 78	2018
157	Das S.	φ meson production at forward rapidity in Pb-Pb collisions at \sqrt{ s_NN}=2.76 TeV	Eur. Phys. J. C 78	2018
158	Das S.	Energy dependence and fluctuations of anisotropic flow in Pb-Pb collisions at \sqrt{s_NN } =5.02 and 2.76 TeV	JHEP 07	2018
159	Das S.	Inclusive J/ψ production at forward and backward rapidity in p-Pb collisions at \sqrt{s_NN}= 8.16 TeV -	JHEP 07	2018
160	Das S.	Anisotropic flow in Xe-Xe collisions at \sqrt{s_NN}=5.44 TeV	Phys. Lett. B784	2018
161	Das S.	Neutral pion and η meson production in p-Pb collisions at \sqrt{s_NN}=5.02 TeV -	Eur. Phys .J. C78	2018
162	Das S.	Inclusive J/ψ production in Xe-Xe collisions at \sqrt{s_NN}= 5.44 TeV	Phys. Lett. B 785	2018
163	Das S.	Anisotropic flow of identified particles in Pb-Pb collisions at \sqrt{s_NN}=5.02 TeV	JHEP09	2018
164	Das S.	Azimuthally-differential pion femtoscopy relative to the third harmonic event plane in Pb-Pb collisions at \sqrt{s_NN} = 2.76 TeV	Phys. Lett. B 785	2018
165	Das S.	Dielectron production in proton-proton collisions at \sqrt{ } = 7 TeV	JHEP	2018
166	Das S.	Neutral pion and η meson production at mid-rapidity in Pb-Pb collisions at \sqrt{ sNN} = 2.76 TeV	Phys. Rev. C 98	2018
167	Das S.	Medium modification of the shape of small-radius jets in central Pb-Pb collisions at \sqrt{ _NN}=2.76TeV -	JHEP 10	2018
168	Das S.	Transverse momentum spectra and nuclear modification factors of charged particles in pp, p-Pb and Pb-Pb collisions at the LHC	JHEP	2018
169	Das S.	Transverse momentum spectra and nuclear modification factors of charged particles in Xe-Xe collisions at \sqrt{s _NN} = 5.44 TeV	Phys. Lett. B 788	2019
170	Das S.	Measuring $K^0_S K^\pm$ interactions using pp collisions at \sqrt (sNN }=7 TeV	Phys. Lett. B 790	2019

Research Papers / Books Published

171	Das S.	Y suppression at forward rapidity in Pb-Pb collisions at NN√ = 5.02 TeV -	Phys. Lett. B 790	2019
172	Das S.	Direct photon elliptic flow in Pb-Pb collisions at \sqrt{s _NN}= 2.76 TeV	Phys. Lett. B 789	2019
173	Das S.	Charged jet cross section and fragmentation in proton-proton collisions at \sqrt{sNN} = 7 TeV	JHEP 1902	2019
174	Das S.	Direct photon production at low transverse momentum in proton-proton collisions at \sqrt{sNN }=2.76 and 8 TeV	Phys. Rev. C 99	2019
175	Das S.	Dielectron and heavy-quark production in inelastic and high-multiplicity proton-proton collisions at \sqrt{sNN } = 13 TeV	Phys. Lett. B 788	2019
176	Das S.	Suppression of Λ\(1520) resonance production in central Pb-Pb collisions at \sqrt{s_NN} = 2.76 TeV	Phys. Rev. C 99	2019
177	Das S.	Multiplicity dependence of light-flavor hadron production in pp collisions at \sqrt{ }= 7 TeV	Phys. Rev. C 99	2019
178	Das S.	p-p, p-Λ and Λ-Λ correlations studied via femtoscopy in pp reactions at \sqrt{ } = 7 TeV	Phys. Rev. C 99	2019
179	Das S.	Measurement of dielectron production in central Pb-Pb collisions at \sqrt{s_NN} = 2.76 TeV	Phys. Rev. C 99	2019
180	Das S.	Azimuthal anisotropy of heavy-flavour decay electrons in p-Pb collisions at \sqrt{s _NN} = 5.02 TeV	Phys. Rev. Lett. 122	2019
181	Das S.	Centrality and pseudorapidity dependence of the charged-particle multiplicity density in Xe-Xe collisions at \sqrt{ s_NN}= 5.44 TeV	Phys. Lett. B 790	2019
182	Mukherjee R, Dutta A and Sinha T P	Octahedral distortion-driven electrical and vibrational properties of A2ErTaO6 (A = Sr and Ca) double perovskite oxides	Journal of Advanced Dielectrics	2018
183	Sheikh Md S, Chanda S, Dutta A, Das S and Sinha T P	Schottky diode like behaviour in Ag/Dy2NiMnO6/FTO device	Materials Today: Proceedings	2018
184	Saha S, Maity R, Sakhya A P, Chanda S, Dutta A and Sinha T P	Ac Conductivity And Raman Spectroscopic Studies Of PrMnO3 Nanostructure	Materials Today: Proceedings	2018
185	Maitya R, Sakhya A P, Dutta A and Sinha T P	Investigation of concentration dependent electrical and photocatalytic properties of Mn doped SmFeO3	Materials Chemistry and Physics	2019
186	Maity R, Sakhya A P, Dutta A and Sinha T P	Effect of Sm doping on the structural, morphological and dielectric properties of EuFeO3 ceramics	Solid State Sciences	2019
187	Sheikh Md S, Sakhya A P, Maity R, Dutta A and Sinha T P	Narrow band gap and optical anisotropy in double perovskite oxide Sm2NiMnO6: A new promising solar cell absorber	Solar Energy Materials and Solar Cells	2019
188	Rudra M, Halder S, Saha S, Dutta A and Sinha T P	Temperature dependent conductivity mechanisms observed in Pr2NiTiO6	Materials Chemistry and Physics	2019

Research Papers / Books Published

PLANT BIOLOGY				
189	Mukherjee D, Mitra A, Ghosh A	Detection of apoptosis like cell death in *Ustilago maydis* by annexin V-FITC staining	Bioprotocol	2018
190	Mukherjee Amrita, Mazumder Mrinmoy, Jana Jagannath, Srivasatava Archana Kumari, Mondal Banani, De Aishee, Ghosh Swagata, Saha Upala, Bose Rahul, Chatterjee Subhrangsu, Dey Nrisingha, and Basu Debabrata	Enhancement of ABA sensitivity through conditional expression of ARF10 gene in *Brassica juncea* exhibit fertile plants with tolerance against *Alternaria brassicicola*	International Soci for Molecular Plant Microbe Interaction	2019
191	Sultana M and Gangopadhyay G	Early expression of WUSCHEL is a marker for in vitro shoot morphogenesis in tobacco and *Beta palonga*	Plant Cell Tissue and Organ Culture	2018
192	Bose S, Gangopadhyay G and Sikdar SR	RiHSPRO2, a nematode resistance protein-like homolog from a wild crucifer *Rorippa indica* (L.) Hiern, is a promising candidate to control mustard aphid *Lipaphis erysimi.*	Arthropod-Plant Interactions	2018
193	Bose S, Gangopadhyay G and Sikdar SR	*Rorippa indica HSPRO2* expression in transgenic *Brassica juncea* induces tolerance against mustard aphid *Lipaphis erysimi*	Plant Cell Tissue and Organ Culture	2019
194	Dutta D and Gangopadhyay G	*Sesamum mulayanum* NAC domain-containing protein 43 (NAC43) mRNA, partial cds	GenBank Accession	2018
195	Dutta D and Gangopadhyay G	Sesamum mulayanum V-type proton ATPase subunit C-like protein (VPA) mRNA, partial cds	GenBank Accession	2018
196	Dutta D and Gangopadhyay G	*Sesamum mulayanum* ferric reduction oxidase (FRO) mRNA, partial cds.	GenBank Accession	2018
197	Dutta D and Gangopadhyay G	*Sesamum prostratum* centroradialis mRNA, partial cds	GenBank Accession	2018
198	Awon V K, Dutta D and Gangopadhyay G	*Sesamum mulayanum* NBS-LRR class resistance protein mRNA, partial cds	GenBank Accession	2018
199	Dutta D and Gangopadhyay G	*Sesamum mulayanum* omega 6 fatty acid desaturase (FAD) mRNA, partial cds	GenBank Accession	2018
200	Dutta D and Gangopadhyay G	*Sesamum mulayanum* polyphenol oxidase (PPO) mRNA, partial cds	GenBank Accession	2018
201	Dutta D and Gangopadhyay G	*Sesamum mulayanum* sesamin synthase (SS) mRNA, partial cds	GenBank Accession	2018
202	R Mallik, A Kundu, S Chaudhuri	High mobility group proteins: the multifaceted regulators of chromatin dynamics	The Nucleus	2018
203	D Roy, J Chakrabarty, R Mallik, S Chaudhuri	Rice Trithorax factor ULTRAPETALA 1 (OsULT1) specifically binds to "GAGAG" sequence motif present in Polycomb response elements	Biochimica et Biophysica Acta (BBA)-Gene Regulatory Mechanisms	2019
204	P Dasgupta, S Chaudhuri	Analysis of DNA Methylation Profile in Plants by Chop-PCR	Plant Innate Immunity	2019
205	A Paul, S Chaudhuri	Change in Nucleosome Dynamics During Stress Responses in Plants	Plant Innate Immunity	2019
LIBRARY				
206	Chakraborty AK	Role of Public Libraries as Community Information Hub/ ESHONA	J. of Gurudas College	2018

PUBLICATIONS OF SENIOR SCIENTISTS:

Prof. A.N.Lahiri Majumder, INSA Senior Scientist (upto February 28,2019); INSA Honorary Scientist (Since March 01, 2019) (Division of Plant Biology)				
207	Das P, Majumder A L	Transcriptome analysis of grapevine under salinity and identification of key genes responsible for salt tolerance	Functional & Integrative Genomics	2018
208	Basak P, Sangma S, Mukherjee A, Agarwal T, Sengupta S, Ray S, Majumder A L	Functional characterization of two myo-inositol-1-phosphate synthase (MIPS) gene promoters from the halophytic wild rice *(Porteresia coarctata*).	Planta	2018
209	Mukherjee S, Sengupta S, Mukherjee A, Basak P, Majumder A L	Abiotic stress regulates expression of galactinol synthase genes post-transcriptionally through intron retention in rice	Planta	2018
210	Mukherjee G, Saha C, Naskar N, Mukherjee A, Mukherjee A, Lahiri S , A L Majumder and Seal A	An Endophytic Bacterial Consortium modulates multiple strategies to improve Arsenic Phytoremediation Efficacy in *Solanum nigrum*	Scientific Reports	2018
211	Mukherjee R, Mukherjee A, Bandyopadhyay S, Mukherjee S, Sengupta S, Ray S and Majumder A L	Selective manipulation of the inositol metabolic pathway for induction of salt-tolerance in *indica* rice variety.	Scientific Reports	2019
Prof. D.Home, NASI Senior Scientist Platinum Jubilee Fellow (Physics)				
212	Kanjilal S, Khan A, Jebarathinam C, and Home D	Remote state preparation using correlations beyond discord	Physical Review A 98	2018
213	Bose S, Home D and Mal S	Nonclassicality of the harmonic-oscillator coherent state persisting up to the macroscopic domain	Physical Review Letters 120	2018
214	Jebarathinam C, Khan A, Kanjilal S and Home D	Revealing the quantitative relation between simultaneous correlations in complementary bases and quantum steering for two-qubit Bell diagonal states	Physical Review A 98	2018
Prof. J.Basu, J.C. Bose National Fellow (Chemistry)				
215	Datta C, Subuddhi A, Kumar M, Lepcha TT, Chakraborty S, Jana K, Ghosh Z, Mukhopadhyay AK, Basu J, Kundu M	Genome-wide mRNA–miRNA profiling uncovers a role of themicroRNA miR-29b-1-5p/PHLPP1 signalling pathway in *Helicobacter pylori*-driven matrix metalloproteinase productionin gastric epithelial cells	Cell Microbiol	2018
Prof. Pinakpani Chakrabarti (Biochemistry)				
216	Bera S, Dhar J, Dasgupta R, Basu G, Chakraborti S and Chakrabarti P	Molecular features of interaction involving hen egg white lysozyme immobilized on graphene oxide and the effect on activity	Int J Biol Macromol	2018
217	Dhar J and Chakrabarti P	Structural motif, *topi* and its role in protein function and fibrillation	Mol. Omics	2018
218	Podder S, Chakravarty D and Chakrabarti P	Structural changes in DNA-binding proteins on complexation	Nucleic Acids Res.	2018

Research Papers / Books Published

219	Jana TK, Jana SK, Kumar A, De K, Maiti R, Mandal AK, Chatterjee T, Chatterjee BK, Chakrabarti P and Chatterjee K	The antibacterial and anticancer properties of zinc oxide coated iron oxide nanotextured composites.	Colloids and Surfaces B: Biointerfaces	2019
Prof. Sampa Das, INSA Senior Scientist (Division of Plant Biology)				
220	Chakraborty J, Priya P, Ghosh Dastidar S, Das S	Physical interaction between nuclear accumulated CC-NB-ARC-LRR protein and WRKY64 promotes EDS1 dependent *Fusarium* wilt resistance in chickpea	Plant Sci.	2018
221	Chakraborty J, Ghosh P, Sen S, Das S	Epigenetic and transcriptional control of chickpea WRKY40 promoter activity under *Fusarium* stress and its heterologous expression in *Arabidopsis* leads to enhanced resistance against bacterial pathogen	Plant Sci.	2018
222	Chakraborty J, Ghosh P, Das S	Autoimmunity in plants	Planta	2018
223	Chakraborty J, Ghosh P, Sen S, Nandi A K and S Das	CaMPK9 increases the stability of CaWRKY40 transcription factor which triggers defence response in chickpea upon *Fusarium oxysporum* f. sp. ciceri Race1 infection.	Plant Molecular Biology	2019
224	Das S and S Das	First report of a novel alphapartitivirus in the basidiomycete *Rhizoctonia oryzae sativae*	Archives of Virology	2019
225	Jain A and Das S	Biosafety and regulatory aspects of nanotechnology in agriculture and food	Emerging trends in agri-nanotechnology: fundamental and applied aspects, Edited by H.B. Singh et. Al.	2018
226	Jain A, and Das S	Fungal diseases of some important medicinal plants	Diseases of Medicinal and Aromatic Plants and their Managemen,t Edited by R. Pandey, A.K. Misra, H. B. Singh, A. Kalra and D. Singh	2019
Prof. Sushanta Dattagupta, FNA (INSA Senior Scientist)				
227	Aharony A, Entin-Wohlman O, Chaudhuri D and Duttagupta S	Quantum Phase and its Measurable Attributes *a la* the Aharonov-Bohm Effect, Resonance, Noise a Good Model for the Environment of Mesoscopic Systems?	Journal of Statistical Physics	2019
228	Duttagupta S	Cyclotron Motion and the Enigma of Orbital Magnetism – What Does the Boundary Do?,	Proceedings of the Indian National Science Academy	2019
229	Duttagupta S	Foreign Policy Values (with special reference to U. S. A.)	Values in Foreign Policy, ed. Krishnan Srinivasan et al	2019

STATEMENT OF ACCOUNTS FOR THE YEAR 2018-19

INDEPENDENT AUDITOR'S REPORT

(TO THE MEMBERS OF THE COUNCIL)

Qualified Opinion

We have audited the accompanying financial statements of BOSE INSTITUTE (the entity), which comprise the Balance Sheet at March 31st 2019, and the Income & Expenditure account, Receipts & Payment Account for the year then ended, and notes to the financial statements, including a summary of significant accounting policies and other explanatory information. In our opinion and to the best of our information and according to the explanations given to us, except for the effect of the matter described in the Basis for Qualified Opinion section of our report, the accompanying financial statements give a true and fair view of the financial position of the entity as at March 3Ist, 2019, and of its financial performance for the year then ended.

Basis for Qualified Opinion

1. The institute has accounted for expenses on cash basis in the financial statements in few cases which is contrary to the fundamental accounting assumptions as per as 1 notified by the Institute of Chartered Accountants of India.

2. Intangible assets in the form of books and journals are not amortised over the licence period and are being carried forward and depreciated even after expiry of their licence period which is not in accordance with the requirement of AS **26** notified by the Institute of Chartered Accountants of India. The amount of such expired licences is presently not ascertainable.

3. As reported by the management, fixed asset register was updated upto 31st March 2017 and for the period 1st April, 2017 to 31st March, 2019 is under preparation.

4. Liability towards gratuity and leave encashment is not ascertained as per actuarial valuation and the same are accounted for on cash basis contrary to the requirement of AS 15 notified by the Institute of Chartered Accountants of India.

5. The institute does not have internal audit system commensurate with the size and nature of its activity resulting in poor internal financial control.

6. The institute could not reconcile accrued interest on fixed deposit as per books of accounts with that as per bank confirmation in few cases.

7. We could not verify old brought forward current assets and liabilities amounting to Rs. 484.96 lacs and Rs. 614.67 lacs respectively. Consequential impact on the year's revenue and the net current asset position as at the end of the year is not ascertainable.

8. Asset acquired from development and modernisation fund amounting to Rs. 666.57 lacs has been held under 'Investment Under Earmarked Fund' and has not been capitalised thereby understating the fixed assets to that extent. Consequential impact on depreciation and current year's profitability is not ascertainable.

9. We could not verify old brought forward capital work in progress amounting to Rs. 2.62 lacs which need immediate review and adjustments in the books of accounts. Consequential impact on the books of accounts is not ascertainable at this stage.

10. The Professional Tax Return is not reconciled with the books of accounts.

We conducted our audit in accordance with the Standards on Auditing (SAs) issued by ICAI. Our responsibilities under those standards are further described in the Auditor's Responsibilities for the Audit of the Financial Statements section of our report. We are independent of the entity in accordance with the ethical requirements that are relevant to our audit of the financial statements in India, and we have fulfilled our other ethical responsibilities in accordance with these requirements. We believe that the audit evidence we have obtained is sufficient and appropriate to provide a basis for our qualified opinion.

Responsibilities of Management and Those Charged with Governance for the Financial Statements

Management is responsible for the preparation and fair presentation of the financial statements in accordance with the aforesaid Accounting Standards, and for such internal control as management determines is necessary to enable the preparation of financial statements that are free from material misstatement, whether due to fraud or error. In preparing the financial statements, management is responsible for assessing the entity's ability to continue as a going concern, disclosing, as applicable, matters related to going concern and using the going concern basis of accounting unless management either intends to liquidate the entity or to cease operations, or has no realistic alternative but to do so. Those charged with governance are responsible for overseeing the entity's financial reporting process.

Our objectives are to obtain reasonable assurance about whether the financial statements as a whole are free from material misstatement, whether due to fraud or error, and to issue an auditor's report that includes our opinion.

Reasonable assurance is a high level of assurance, but is not a guarantee that an audit conducted in accordance with SAs will always detect a material misstatement when it exists. Misstatements can arise from fraud or error and are considered material if, individually or in the aggregate, they could reasonably be expected to influence the economic decisions of users taken on the basis of these financial statements.

Place: Kolkata

Date: 13/09/2019

For Ray & Ray

Chartered Accountants
FRN : 301072F

CA Abhijit Neogi
Membership No : 061380
UDIn: 19061380AAAAAM2090

BOSE INSTITUTE
KOLKATA

Balance Sheet as on 31st March, 2019

(Amount in ₹)

	Schedule	2018-19 ₹	2017-18 ₹
Corpus /Capital fund and liabilities			
Corpus /Capital fund	**1**	2,94,01,85,863.66	2,83,96,89,566.02
Reserves and surplus	**2**		
Earmarked/Endowment funds	**3**	54,92,84,812.41	57,64,07,803.51
Secured loans and borrowings	**4**		
Unsecured loans and borrowings	**5**		
Deferred credit liabilties	**6**		
Current liabilities and provisions	**7**	69,13,85,263.47	64,89,53,625.08
Total		**4,18,08,55,939.54**	**4,06,50,50,994.61**
Assets			
Fixed Assets	**8**	89,55,49,811.15	90,90,76,430.47
Investments-others	**9**	35,69,26,095.28	38,74,37,146.42
Investments -from earmarked/ endowment Funds	**10**	13,25,14,044.04	12,92,89,294.00
Current assets,loans,advances etc.	**11**	2,79,58,65,989.07	2,63,92,48,123.72
Miscellaneous expenditure (to the extent not written off or adjusted)			
Total		**4,18,08,55,939.54**	**4,06,50,50,994.61**
Significant accounting policies	**24**		
Contingent liabilities and notes on accounts	**25**		

Place : Kolkata
Date : 13/09/2019

Signed in terms of our separate Report of even date.
For Ray & Ray
Chartered Accountants
Firm Registration No 301072E

Abhijit Neogi
Partner
Membership No.61380

Sd/-
Shaubhik Ghosh
UDC-I

Sd/-
Kamal Sing
Accounts Officer (Cash)

Sd/-
Vikash Kumar
Audit & Finance Officer

Sd/-
Achintya Mukherjee
Accounts Officer

Sd/-
Dr. Anup Kumar Misra
Registrar(O)

Sd/-
Prof. (Dr.) Uday Bandyopadyay
Director

BOSE INSTITUTE

INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED 31.03.2019

	Schedules	2018-19 ₹	2017-18 ₹
INCOME			
Income from Sales and Services	**12**	71,86,260.00	72,51,000.00
Grants/Subsidies	**13**	97,00,19,000.00	81,75,50,000.00
Fees/Subscriptions	**15**		
Income from Investments (Income on Investment, from earmarked /endowment Funds transferred to Funds)	**14**	4,05,90,558.04	2,54,60,213.40
Income from royalty, publication etc .	**16**		
Interest Earned	**17**		
Other Income	**18**	29,36,164.52	13,24,577.00
Increase/ (decrease) in stock of Finished goods and work-in-progress	**19**		
Total (A)		**1,02,07,31,982.56**	**85,15,85,790.40**
EXPENDITURE			
Establishment Expenses	**20**	57,19,87,086.00	49,66,37,165.43
Other Administrative Expenses	**21**	22,85,78,525.81	22,22,72,655.86
Expenditure on Grant, Subsidies etc.	**22**	-	
Interest	**23**		
Fund for capital Expenditure	**23A**	5,00,94,223.64	6,35,58,313.00
Depreciation (Net Total at the year end corresponding to Schedule 8)		6,31,38,498.64	5,79,44,282.00
Total (B)		**91,37,98,334.09**	**84,04,12,416.29**
Balance being excess of Income over Expenditure (A-B)		10,69,33,648.47	1,11,73,374.11
Transfer to Special Reserve (Specify each)			
Last Year Unspent Balance /overspent balance		-20,27,68,596.63	-21,50,67,284.67
Balance of Unspent Balance After Adjustment		-20,27,68,596.63	-21,50,67,284.67
Balance being Surplus/(deficit) carried to corpus /capital fund		**-9,58,34,948.16**	**-20,38,93,910.56**
Significant accounting policies	24		
Contingent liabilities and notes on accounts	25		

Place : Kolkata
Date : 13/09/2019

Signed in terms of our separate Report of even date.
For Ray & Ray
Chartered Accountants
Firm Registration No 301072E

Abhijit Neogi
Partner
Membership No.61380

Sd/- Shaubhik Ghosh UDC-I	Sd/- Kamal Sing Accounts Officer (Cash)	Sd/- Vikash Kumar Audit & Finance Officer
Sd/- Achintya Mukherjee Accounts Officer	Sd/- Dr. Anup Kumar Misra Registrar(O)	Sd/- Prof. (Dr.) Uday Bandyopadyay Director

BOSE INSTITUTE

RECEIPT AND PAYMENT ACCOUNTS FOR THE YEAR ENDED 31.03.2019 (COUNCIL A/C)

Receipts	Schedule no	Amount (₹)	Payments	Schedule no	Amount (₹)
Opening Balance	1	10,97,67,385.64			
Receipt against Establishment Expenses	2	10,29,807.00	Establishment Expenses	2	60,28,27,613.00
Receipt against Laboratory Expenses	3	4,46,83,366.00	Laboratory Expenses	3	8,47,31,435.86
			Other Adminstrative Expenses	4	12,97,07,623.74
Receipt Against Other Adminstrative Expenses	4	6,23,944.00			
			Payments for the current assets	5	3,25,64,185.00
Receipt from Indirect Income	9	1,50,46,564.38	Payments for the Fixed assets	6	4,38,65,406.64
Receipt from other Assets		12,09,825.00			
Receipt from Current Assets	5	3,45,68,023.75			
Receipts from Statutory Liabilities	7	8,03,08,875.30	Payment for Current Liabilties & Statutory	7	10,78,59,248.00
Receipts from Current Liabilties & other Liabilities	8	1,81,31,887.00			
			Payment for other Liabilities	8	95,55,583.00
			Payment from earmarked fund		1,14,607.00
			Payment for other income	9	7,48,930.00
Inter Unit Account			**Inter Unit Account**		
			FAIR		
			Scheme/Project Grant in _aid		
Scheme/Project		-	Scheme/Project		2,78,43,821.00
Scheme/Project Grant in _aid		92,20,62,000.00	St_Rural		3,10,999.00
St_Rural		1,04,602.00	Governing Body		43,400.00
Governing Body		-	Closing Balance	1	18,73,63,427.83
		1,22,75,36,280.07			**1,22,75,36,280.07**

For Ray & Ray
Chartered Accountants
Firm Registration No 301072E

Sd/-
Abihijit Neogi
Partner
Membership No. 61380

Sd/-	Sd/-	Sd/-	Sd/-
Shaubhik Ghosh	Kamal Sing	Vikash Kumar	Achintya Mukherjee
UDC-1	Accounts Officer (Cash)	Audit & Finance Office	Accounts Officer

BOSE INSTITUTE
KOLKATA

Receipt and Payment accounts for the year ended 31.03.2019 (Projects)

Receipts	Sch. No.	Amount (₹)	Payments	Sch. No.	Amount (₹)
OPENING BALANCE		**83,43,74,808.45**	Payment from Projects	2	17,51,77,746.85
Receipt from projects	2	18,51,94,369.00	Payment from Adhoc/RA/PDF	3	2,91,87,141.33
Receipt from projects from Adhoc /Ra / Pdf	3	2,59,84,974.00	Payment for other than Project	4	38,10,209.00
Receipts from Other Than Scheme / Projects	4	63,55,498.00			
Receipts from IFCC	5	4,41,10,395.32	Payment OF IFCC	6	11,26,38,159.82
Fixed Deposit(IFCC)			Payment OF ST Rural	8	4,62,78,051.69
Receipts from St Rural	7	6,20,28,715.69			
			Receivable From Scholors		1,159.00
Receivable From Scholors		5,010.00			
Branch /InterUnit			**Branch /InterUnit**		
Bose Institute		1,04,04,66,361.00	Bose Institute		97,41,82,658.36
IFCC		80,00,000.00	Bank Charges		
Interest on FD			AUTOSWEEP NO 416603350009396		
Interest on SB 3355			AUTOSWEEP NO 416603350009413		
Pick Up Service					
AUTOSWEEP NO 416603350009396					
AUTOSWEEP NO 416603350009413					
Bank Charges					
			CLOSING BALANCE		86,52,45,005.41
		2,20,65,20,131.46			**2,20,65,20,131.46**

For Ray & Ray
Chartered Accountants
Firm Registration No 301072E

Sd/-
Abihijit Neogi
Partner
Membership No. 61380

Sd/-
Sukanta Chakraborty
Accountant

Sd/-
Vikash Kumar
Audit & Finance Office

Sd/-
Achintya Mukherjee
Accounts Officer

BOSE INSTITUTE
KOLKATA

Bose Institute Employees' Pension Fund
For the year ended on 31st March, 2019
Income Expenditure

For the year ended 31st March 2018 (₹)	Expenditure	For the year ended 31st March 2019 (₹)	For the year ended 31st March 2018 (₹)	Income	For the year ended 31st March 2019 (₹)
12,67,30,442.00	To Pension Account	12,55,35,025.00	15,09,19,130.00	By Contribution from Bose Institute	
1,03,95,898.00	To Gratuity Account	4,10,90,165.00		For Pension & Gratuity	20,21,83,678.00
67,19,506.00	To Pension Commutation	4,16,53,612.00		By Contribution from Other Organisation	
0.00	To Bank Charges	-		For Pension & Gratuity By Interest	–
	To Lose on Fixed Deposit	56,324.00	59,34,415.00	Fixed Deposit with Bank	88,39,755.56
			3,17,278.00	Savings Bank Account	2,61,210.00
1,33,24,977.00	To Excess of Income over Expenditure	29,49,517.56			
15,71,70,823.00		**21,12,84,643.56**	**15,71,70,823.00**		**21,12,84,643.56**

Bose Institute Employees' Pension Fund
Balance Sheet as on 31st March, 2019

As at 31st March 2018 (₹)	Liabilities	As at 31st March 2019 (₹)	As at 31st March 2018 (₹)	Assets	As at 31st March 2019 (₹)
13,30,13,374.05	Balance As per last A/c	14,63,38,351.05	11,93,29,312.00	Fixed Deposit	13,52,85,611.19
1,33,24,977.00	Add: Excess of Income over Expenditure	29,49,517.56	14,02,091.00	Accrued Interest (F.D)	14,01,411.56
3,66,830.00	Payable to Pensioner	3,66,830.00	1,48,76,784.19	" Bank Balance With S.B.I Savings Bank Account "	1,04,890.00
	TDS pension	-	1,10,59,564.86	Receivable from Bose Institute Council	1,56,46,257.86
0.00	Payable to Bose Institute	-	21,429.00	Receivable From Employees	(13.00)
0.00	Liability towards 30%	2,799.459.00	16,000.00	TDS Pension	16,000.00
14,67,05,181.05		**15,24,54,157.61**	**14,67,05,181.05**		**15,24,54,157.61**

For Ray & Ray
Chartered Accountants
Firm Regisration No 301072E

Sd/-
Abihijit Neogi
Partner
Membership No. 61380

Sd/-	Sd/-	Sd/-	Sd/-	Sd/-
Shaubhik Ghosh	Vikash Kumar	Achintya Mukherjee	Prof. Anup Kumar Misra	Prof. (Dr.) Uday Bandyopadhyay
UDC-1	Audit & Finance Office	Accounts Officer	Registrar (O)	Director

BOSE INSTITUTE
KOLKATA

Bose Institute Employees' General Provident Fund
Income and Expenditure Account for the year ended 31/03/2019

for the financial year 2018-19

31-3-2018 Amount (₹)	Expenditure	31-3-2019 Amount (₹)	31-3-2018 Amount (₹)	Income	31-3-2019 Amount (₹)
1,48,12,056.00	Interest Paid to Members	1,36,62,420.00	1,68,41,055.00	Interest on Fixed Deposit	1,53,74,714.00
	Loss on Fixed Deposit	1,27,471.00			
–	Bank Charges	17.70	1,95,264.00	Interest on savings Bank Accounts	3,86,471.00
22,24,263.00	Excess of Income Over Expenditure	19,71,276.30			
1,70,36,319.00		**1,57,61,185.00**	**1,70,36,319.00**		**1,57,61,185.00**
				Excess of Income over Expenditure	
			1,36,52,969.64	Brought forward from previous year	1,58,77,232.64
1,58,77,232.64	Excess of Income over Expenditure transferred to Balance Sheet	1,78,48,508.94	22,24,263.00	Excess of Income over Expenditure Brought forward from current year	19,71,276.30
1,58,77,232.64		**1,78,48,508.94**	**1,58,77,232.64**		**1,78,48,508.94**

For Ray & Ray
Chartered Accountants
Firm Regisration No 301072E

Sd/-
Abihijit Neogi
Partner
Membership No. 61380

Sd/-
Shaubhik Ghosh
UDC-1

Sd/-
Vikash Kumar
Audit & Finance Office

Sd/-
Achintya Mukherjee
Accounts Officer

Sd/-
Prof. Anup Kumar Misra
Registrar (O)

Sd/-
Prof. (Dr.) Uday Bandyopadhyay
Director

BOSE INSTITUTE
KOLKATA

Bose Institute Employees' General Provident Fund
Kolkata
Balance Sheet as on 31st March, 2019

2017-18 Amount (₹)	Liabilities	2018-19 Amount (₹)	2017-18 Amount (₹)	Assets	2018-19 Amount (₹)
19,54,78,470.31	GPF Accumulation Capital Fund Balance Brought Forward	20,30,76,706.31	20,80,44,741.00	Fixed Deposit with State Bank of India	19,11,74,741.00
	Add: Refund of Advance Adjusted with Accumulated profit	31,460.00		Advance Outstanding from Members	18,49,335.00
2,12,83,754.00	Add: Subscription by members during the year	2,81,25,773.00	25,02,349.00	Add: Refund Of Advance Adjusted with Accumulated profit	31,460.00 18,80,795.00
1,48,12,056.00	Add: Interest Paid to members	1,36,62,420.00	18,04,230.00	Interest Accrued but not received from on Fixed Deposit	13,85,479.00
23,15,74,280.31		24,48,96,359.31			
			54,92,566.95	Bank Balance with SBI	1,06,562.25
2,84,97,574.00	Less:Withdrawal	7,68,84,796.00			
20,30,76,706.31		16,80,11,563.31	40,48,706.00	Receiavable from Bose Institute	60,05,296.00
1,58,77,232.64	Add: Excess of Income over Expenditure transferred from Income Expenditure Account	1,78,48,508.94			
29,38,654.00	Payable to Bose Institute	1,44,28,501.00			
	Payable to CPF	2,64,300.00			
22,18,92,592.95		**20,05,52,873.25**	**22,18,92,592.95**		**20,05,52,873.25**

For Ray & Ray
Chartered Accountants
Firm Regisration No 301072E

Sd/-
Abihijit Neogi
Partner
Membership No. 61380

Sd/-
Shaubhik Ghosh
UDC-1

Sd/-
Vikash Kumar
Audit & Finance Office

Sd/-
Achintya Mukherjee
Accounts Officer

Sd/-
Prof. Anup Kumar Misra
Registrar (O)

Sd/-
Prof. (Dr.) Uday Bandyopadhyay
Director

BOSE INSTITUTE
KOLKATA

Bose Institute Employees' Contributory Provident Fund
Kolkata
Balance Sheet as on 31st March, 2019

2017-18 Amount (₹)	Liabilities	2018-19 Amount (₹)	2017-18 Amount (₹)	Assets	2018-19 Amount (₹)
1,66,52,589.75	Capital Fund	29,07,491.75	1,54,65,719.00	Fixed Deposit	26,00,000.00
4,51,247.00	Profit & Loss as per Income & Expenditurte	7,80,071.00	8,21,835.75	Bank Balance at SBI	3,31,782.75
-	Payble to staff	2,02,160.00	1,22,919.00	Accured Interest	14,244.00
200.00	Loans	23,300.00	4,52,363.00	Receivable from staff	7,02,696.00
			2,41,200.00	Receivable from GPF	2,64,300.00
1,71,04,036.75		**39,13,022.75**	**1,71,04,036.75**		**39,13,022.75**

Bose Institute Employees' Contributory Provident Fund
Income and Expenditure Account for the year ended 31/03/2019

31-3-2018 Amount (₹)	Expenditure	31-3-2019 Amount (₹)	31-3-2018 Amount (₹)	Income	31-3-2019 Amount (₹)
11,53,837.00	Interest credited to Members:	2,05,569.00	11,71,952.00	Interest earned on Investment CPF	5,34,393.00
18,115.00	Balance	3,28,824.00			
11,71,952.00		**5,34,393.00**	**11,71,952.00**		**5,34,393.00**
			18,115.00	Balance c/f	3,28,824.00
4,51,247.00	Profit & Loss	7,80,071.00	4,33,132.00	Excess of Income over Expenditure	4,51,247.00
4,51,247.00		**7,80,071.00**	**4,51,247.00**		**7,80,071.00**

For Ray & Ray
Chartered Accountants
Firm Regisration No 301072E

Sd/-
Abihijit Neogi
Partner
Membership No. 61380

Sd/-
Vikash Kumar
Audit & Finance Office

Sd/-
Achintya Mukherjee
Accounts Officer

Sd/-
Prof. Anup Kumar Misra
Registrar (O)

Sd/-
Uday Bandyopadhyay
Director

SIGNIFICANT ACCOUNTING POLICIES & NOTES ON ACCOUNTS

Schedule :

1.0 Change in Accounting Policy:

The Balance Sheet has been drawn by consolidating Statement of Accounts of Council and the Governing Body with schedules thereon without incorporating the consolidated transactions in the Income and Expenditure Account. Further, the transactions of the Governing Body have not been incorporated in the books of Council. This principle of accounting has been consistently followed from year to year. In case of Governing Body, Pension Fund, Regional Sephisticated Instrumentation Centre and Indo FAIR Coordination Centre, since no format was prescribed for Annual Accounts, they are maintained in the same format as before. The accompanying financial statements have been prepared on historical cost convention and conform to the fundamental accounting assumptions.

2.0 Fixed Assets:

2.1 Land at Madhyamgram

The Institute got possession of 18.73 acres out of 40.99 acres land allotted for Experimental Farm by Govt. of West Bengal. The Governing Body of the Institute decided on 31.07.1989 not to claim the balance land in dispute from the Government considering other related factors.

2.2 Fixed Asset Register

The Institute has taken initiatives to prepare a comprehensive Fixed Asset Register with the help of an agency. The process is almost in the completion stage. This initiative will also cover the assets acquired in the year 1991-92 from "Institute Development and Modernisation Fund" (provided by Planning Commission). As the Fixed Asset Register will become ready after the finalisation of accounts for the financial year 2018-19, therefore the nomenclatures and order mentioned in Schedule 8 (old form schedule 4) is taken into account.

2.3 Work-in-Progress

The particulars of fixed assets, under construction/installation are given in Schedule 8 (old form schedule 4).

2.4 Import in Progress

Import in Progress has been amounted for on the basis of bank advice on the date of actual payment.

2.5 Valuation of assets

a. The valuation of Fixed Assets has been made at cost less depreciation for the years 1990-91 till date.

b. The assets related to terminated projects have been identified up to 2005-06. Further identification of the assets relating to the years 2006-07 to 2018-19 is in progress and will be included in the Fixed Asset Register.

c. The identification of assets, impaired if any, as required in AS-28 (Ind AS 36) issued by ICAI, has not been done.

3.0 Depreciation:

3.1 As per the requirement of new format depreciation for the year 2018-19 and is charged to Income &Expenditure Account.

3.2 The depreciation is calculated on Written Down Value Method as per the following rates irrespective of dates of putting the same in use:

1.	Building	-	10%
2.	Equipment	-	15%
3.	Books & Journals	-	10%
4.	Furniture	-	10%
5.	Vehicles	-	15%
6.	Air Conditioner	-	10%
7.	Electric Installation	-	10%
8.	Internet	-	60%

4.0 Revenue Recognition & Grant in Aid:

4.1 During financial year 2018-19, Grant-in-Aid for Council has been received under the head General, Salaries and Capital. Grant-in-Aid under General and Salaries have been treated as revenue grant. All incomes other than Government Grant and Bank Interest are accounted for on cash basis. Govt. Grants are accounted for on accrual basis provided the order sanctioning the Grant is received before the end of the financial year.

4.2 The Institute has a system of accounting in respect of expenses for items like Salary, Stipend payable to Research Scholars under Sponsored Project Account, Gratuity, Leave Salary, Rates & Taxes etc. on cash basis. Liabilities for amount payable to suppliers for materials, services and other expenses are accounted for on accrual basis.

4.3 Consumable Stores are charged to expenditure for purchases.

4.4 Revenue expenditure on Scheme/Project and on specific grant are recognised in the accounting period in which the corresponding expenditure and grant arise. Net excess of receipts over expenditure of grants-in-aid schemes, sponsored by various agencies are represented in bank balances.

4.5 Government Grants received during the year are shown in the Income & Expenditure Account and surplus/deficit during the current year is reflected in the Balance Sheet.

5.0 Retirement/Post Retirement and Staff Benefits:

5.1 The interest on loans, being recoverable after realisation of principal amount is accounted for as and when it becomes receivable and the said interest is credited to the House Building Advance Fund. This is done as per Central Govt. Guidelines.

5.2 The Institute has General Provident Fund, Contributory Provident Fund and Pension Schemes.

5.3 Leave encashment, Gratuity, Provident Fund Contribution and Pension are accounted for on cash basis.

6.0 System of Fund Accounts:

6.1 The suggestion of Jt. Secretary and F.A. Dept. of Science and Technology, Govt. of India in the Finance Committee meeting held on 24.09.1996 for managing the Provident Fund through Trust Committee is yet to be implemented.

6.2 Although by virtue of the provision 9 of Bose Institute Employees Pension Scheme Regulations approved by the Dept. of Science and Technology, Govt. of India and Rule 3.3 of Bose Institute Contributory Provident Fund Rules, the Pension Fund, General Provident Fund and Contributory Provident Fund vest with Bose Institute, separate Statement of Account with Income and Expenditure Account & Balance Sheet in respect of GPF and CPF are maintained in New prescribed format.

7.0 Earmarked Funds:

Earmarked Funds shall be treated as a liability on their creation.

Income on investments out of Earmarked Fund is recognised and credited to Earmarked Fund wherever accrued. Any expenditure of a revenue nature which is incurred specifically on selected Scheme/Project it charged to the relevant Earmarked Fund.

8.0 Foreign Currency Transactions:

Transactions in foreign currency are recorded at the exchange rate applicable on the date of transaction.

9.0 Research and Development Costs:

Research and Development costs are charged to the Income & Expenditure Account for the year in which these are incurred.

10.0 Advances:

A sum of included under "Advance Council" is shown in the Balance Sheet under the head Advances (Schedule-11) which include a sum of pending recovery / adjustment prior to.

11.0 Contingent Liability:

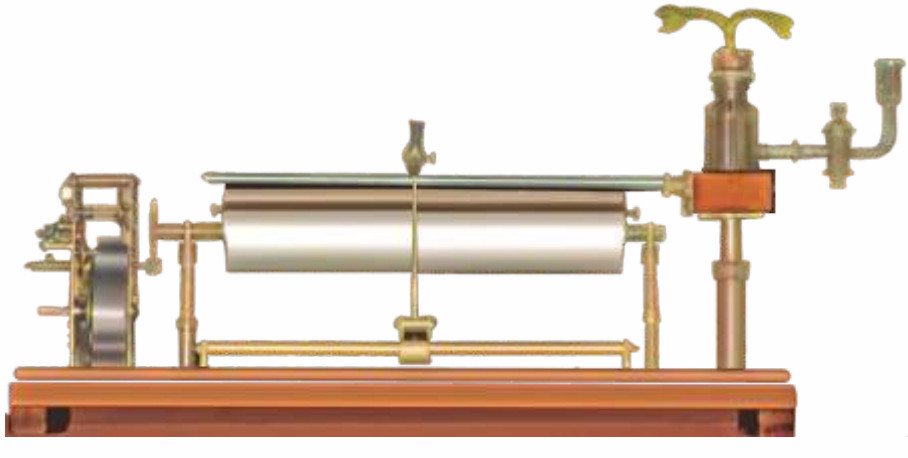
Legal expenses include the cost to defend the court cases lodged against the Institute; contingent liability for such cases is not ascertained.

12.0 Previous year's Figures:

The previous year's figures have been re-grouped and re-arranged in conformity with the figures of current year. Expenses incurred in connection with the Scheduled Tribe Specific Rural Biotechnology Programme and IRHPA Project for the Accounting Year 2013-14 and 2014-15 has been shown separately in Income and Expenditure Account is now adjusted with the Income and Expenditure Account balance 2015-16 of Bose Institute Council Account.

13.0 General Provident Fund:

GPF figures have been reconciled and properly incorporated in accounts having discussion with Statutory Auditor.



INDEPENDENT AUDITOR'S REPORT

(TO THE MEMBERS OF THE COUNCIL)

Opinion

We have audited the accompanying financial statements of BOSE INSTITUTE, Indo-Fair Coordination Centre (the entity), which comprise the Balance Sheet at March 31st 2019, Receipts & Payment Account for the year then ended, and notes to the financial statements, including a summary of significant accounting policies and other explanatory information. In our opinion and to the best of our information and according to the explanations given to us, the accompanying financial statements give a true and fair view of the financial position of the entity as at March 31st, 2019**,** and of its financial performance for the year then ended.

Basis for Opinion

We conducted our audit in accordance with the Standards on Auditing (SAs) issued by ICAI. Our responsibilities under those standards are further described in the Auditor's Responsibilities for the Audit of the Financial Statements section of our report. We are independent of the entity in accordance with the ethical requirements that are relevant to our audit of the financial statements in India, and we have fulfilled our other ethical responsibilities in accordance with these requirements. We believe that the audit evidence we have obtained is sufficient and appropriate to provide a basis for our opinion.

Responsibilities of Management and Those Charged with Governance for the Financial Statements

Management is responsible for the preparation and fair presentation of the financial statements in accordance with the aforesaid Accounting Standards, and for such internal control as management determines is necessary to enable the preparation of financial statements that are free from material misstatement, whether due to fraud or error. In preparing the financial statements, management is responsible for assessing the entity's ability to continue as a going concern, disclosing, as applicable, matters related to going concern and using the going concern basis of accounting unless management either intends to liquidate the entity or to cease operations, or has no realistic alternative but to do so. Those charged with governance are responsible for overseeing the entity's financial reporting process.

Auditor's Responsibilities for the Audit of the Financial Statements

Our objectives are to obtain reasonable assurance about whether the financial statements as a whole are free from material misstatement, whether due to fraud or error, and to issue an auditor's report that includes our opinion.

Reasonable assurance is a high level of assurance, but is not a guarantee that an audit conducted in accordance with SAs will always detect a material misstatement when it exists. Misstatements can arise from fraud or error and are considered material if, individually or in the aggregate, they could reasonably be expected to influence the economic decisions of users taken on the basis of these financial statements.

For Ray & Ray
Chartered Accountants
(Firm Registration No. 301072E)

Date : 13th September, 2019

Place : Kolkata

Abhijit Neogi

Partner
(Membership No : 61380)
UDIN : 19061380 AAA AA M2090

BOSE INSTITUTE (IFCC)
KOLKATA

BALANCE SHEET AS AT 31ST MARCH 2019

As on 31st March 2018 (₹)	Liabilities	As on 31st March 2019 (₹)	As on 31st March 2018 (₹)	Assets	As on 31st March 2019 (₹)
3,26,946.00	Fund for Creation of Asset	3,26,946.00	54,732.00	Shares in FAIR GmbH	54,732.00
			2,72,214.00	Office Equipment	
	Unspent Grant			Furniture : 98,530.00	
22,14,35,585.34	Grant from Department of Science and Technology **(Schedule-1)**	20,06,73,845.34		Equipment :1,73,684.00	2,72,214.00
6,56,71,084.54	Grant from Department of Atomic Energy **(Schedule-2)**	2,44,25975.04	–	Advance	1,94,000.00
			–	Receivable From Bose	
1,58,69,199.00	Interest Earned **(Schedule-3)**	1,75,37,744.00		Institute **Bank Balances**	79,67,510.00
88,500.00	Audit Fees Payable	88,500.00	2,64,33,868.88	S.B. A/c - Union Bank of India	67,07,683.38
• 27,950.00	Payable to Bose Institute	–	27,66,58,450.00	Fixed Deposits	22,78,56,871.00
•					
30,34,19,264.88		**24,30,53,010.38**	**30,34,19,264.88**		**24,30,53,010.38**

STATEMENT OF EXPENDITURE FOR THE YEAR ENDED 31ST MARCH 2019

For the year ended 31st March 2018 (₹)	Particulars	For the year ended 31st March 2019 (₹)
2,49,493.00	Advertisement Expenses	–
-6,908.00	Ad-hoc Bonus	–
88,500.00	Audit Fees	88,500.00
684.74	Bank Charges	1,449.82
37,057.00	Contingency Expenses	50,775.00
1,91,963.00	Meeting Expenses - IFCC	1,01,394.00
2,000.00	Honorarium Expenses	–
2,40,054.00	Fellowship (JRF)	–
12,35,430.00	Salary	8,91,443.00
2,83,945.00	Student Support	–
20,83,750.55	Travelling Expenses	8,72,729.68
4,50,000.00	Overhead Charges	–
3,72,268.00	Workshop	–
52,28,237.29		**20,06,291.50**

Place : Kolkata
Date : 13/09/2019

Signed in terms of our separate Report of even date.
For Ray & Ray
Chartered Accountants
Firm Regisration No 301072E

Sd/-
Abihijit Neogi
Partner
Membership No. 61380

Sd/-	Sd/-	Sd/-	Sd/-	Sd/-
Asish Kumar Dey	Achintya Mukherjee	Prof. Anup Kumar Misra	Uday Bandyopadhyay	Prof. Sanjay Kr. Ghosh
Accounts/Administration Officer, Bose Institute (IFCC)	Accounts Officer	Registrar (O)	Director	Incharge, FAIR Project

STATEMENT OF ACCOUNTS FOR THE YEAR 2018-19

BOSE INSTITUTE (IFCC)
KOLKATA

Receipt and Payment Accounts for the year ended 31.03.2019

Particulars	Amount (₹)	Particulars	Amount (₹)
Opening Balance			
S.B A/c Union Bank of India	2,64,33,868.88		
Fixed Deposits	27,66,58,450.00		
GRANT FROM D.S.T	-		
GRANT FROM D.A.E	-		
GRANT FROM D.S.T (IFCC Exp.)	80,00,000.00		
Interest on SB A/c	5,12,223.00		
Interest on FD (Term Deposits)	1,70,25,521.00		
Advance	10,63,000.00	Advance	12,57,000.00
Profession Tax	4,540.00	Profession Tax	4,540.00
TDS (Salary: ₹ 37297.00 + Party: ₹ 487954.00)	5,25,251.00	TDS (Salary: ₹ 37297.00 + Party: ₹ 487954.00)	5,25,251.00
Travelling Expenses	10,34,455.32	Travelling Expenses	19,07,185.00
Workshop	-	Meeting Expenses - IFCC	1,01,394.00
		Audit Fees (for 2017-18)	88,500.00
		Advertisement Expenses	–
		Bank Charges	1,449.82
		Contingency Expenses	50,775.00
		Overhead Charges	–
		Salary	8,91,443.00
		Student Support	–
		Workshop	–
		Office Equipment	–
		Power Converter (In-Kind)	2,49,82,332.00
		Detector (FAIR Experiment)	5,08,18,779.00
		Vaccum Chamber (In-Kind)	1,49,592.00
		Beam Stopper (In-Kind)	79,02,220.00
		GRANT FROM D.S.T (IFCC Exp.) (Return of Bank Interest for the Year 2017-18)	16,834.00
Inter Unit Account		**Inter Unit Account**	
Bose Institute (Council)	4,540.00	Bose Institute (Council)	-
Scheme/Project	-	Scheme/Project	80,00,000.00
		Closing Balance	
		S.B A/c : Union Bank of India	67,07,683.38
		Fixed Deposits	22,78,56,871.00
	33,12,61,849.20		**33,12,61,849.20**

Place : Kolkata
Date : 13/9/2019

Sd/-
Asish Kumar Dey
Accounts/Administration Officer
Bose Institute (IFCC)

Sd/-
Achintya Mukherjee
Accounts Officer

INDEPENDENT AUDITORS' REPORT

TO THE MEMBERS OF THE COUNCIL

Qualified Opinion

We have audited the accompanying financial statements of BOSE INSTITUTE Governing Body (the entity), which comprise the Balance Sheet at March 31st 2019, and the Income Expenditure account and notes to the financial statements, including a summary of significant accounting policies and other explanatory information. In our opinion and to the best of our information and according to the explanations given to us, except for the effect of the matter described in the Basis for Qualified qrinion section of our report, the accompanying financial statements give a true and fair view of the financial position of the entity as at March 3Ist, 2019, and of its financial performance for the year then ended.

Basis for Qualified Opinion

1. No fixed asset register was provided for our verification. The institute has not carried out test of impairment, if any, in accordance with the requirement of AS 28 notified by the Institute of Chartered Accountants of India.
2. No cash balance certificate as on 3Ist March, 2019 was provided for our verification.
3. Share certificate for investment in 7.5% preference Shares of CESC Limited was not available for our verification.

We conducted our audit in accordance with the Standards on Auditing (SAs) issued by ICAI. Our responsibilities under those standards are further described in the Auditor's Responsibilities for the Audit of the Financial Statements section of our report. We are independent of the entity in accordance with the ethical requirements that are relevant to our audit of the financial statements in India, and we have fulfilled our other ethical responsibilities in accordance with these requirements. We believe that the audit evidence we have obtained is sufficient and appropriate to provide a basis for our qualified opinion.

Responsibilities of Management and Those Charged with Governance for the Financial Statements

Management is responsible for the preparation and fair presentation of the financial statements in accordance with the aforesaid Accounting Standards, and for such internal control as

management determines is necessary to enable the preparation of financial statements that are free from material misstatement, whether due to fraud or error. In preparing the financial statements, management is responsible for assessing the entity's ability to continue as a going concern; disclosing, as applicable, matters related to going concerti and using the going concern basis of accounting unless management either intends to liquidate the entity or to cease operations, or has no realistic alternative but to do so. Those charged with governance are responsible for overseeing the entity's financial reporting process.

Auditor's Responsibilities for the Audit o f the Financial Statements

Our objectives are to obtain reasonable assurance about whether the financial statements as a whole are free from material misstatement, whether due to fraud or error, and to issue an auditor's report that includes our opinion. Reasonable assurance is a high level of assurance, but i s not a guarantee that an audit conducted in accordance with SAs will always detect a material misstatement when it exists. Misstatements can arise from fraud or error and are considered material if, individually or in the aggregate, they could reasonably be expected to influence the economic decisions of users taken on the basis of these financial statements.

For Ray & Ray
Chartered Accountants
(Firm Registration No. 301072E)

Date : 13th September, 2019

Place : Kolkata

Abhijit Neogi

Partner
(Membership No : 61380)
UDIN : 19061380AAAAAN3045

BOSE INSTITUTE (GOVERNING BODY)

93/1, ACHARYA PRAFULLA CHANDRA ROAD, KOLKATA - 700009

BALANCE SHEET AS AT 31ST MARCH 2019

	Schedule No.	As on 31/03/2019	As on 31/03/2018
FUNDS & LIABILITIES		(₹)	(₹)
CAPITAL FUND			
AS PER LAST ACCOUNT		23,17,833.36	23,17,833.36
ACHARYA JC BOSE CENTENARY FUND			
AS PER LAST ACCOUNT		15,99,768.40	15,99,768.40
SPECIAL FUND	1	29,72,629.96	29,82,629.96
DEPOSITS & OTHER LIABILITIES	2	12,16,616.66	12,15,616.66
	TOTAL	**81,06,848.38**	**81,15,848.38**
PROPERTIES & ASSETS			
FIXED ASSETS			
AS PER LAST ACCOUNT	3	23,74,712.85	23,74,712.85
INVESTMENTS			
AS PER LAST ACCOUNT	4	83,19,249.67	63,19,249.67
RECEIVABLE & DEPOSITS			
AS PER LAST ACCOUNT	5	7,01,177.00	3,19,604.00
CASH & BANK BALANCES	6	11,99,762.34	11,88,261.34
INCOME & EXPENDITURE A/C			
EXCESS OF EXPENDITURE OVER INCOME		(24,88,053.48)	(20,85,979.48)
	TOTAL	**81,06,848.38**	**81,15,848.38**

INCOME & EXPENDITURE STATEMENT FOR THE YEAR ENDED 31ST MARCH 2019

Particulars	2018-19 (₹)	2017-18 (₹)
INCOME		
INTEREST ON TERM DEPOSIT	4,36,123.00	5,58,967.00
INTEREST ON SAVINGS BANK		4,365.00
TOTAL	**4,36,123.00**	**5,63,332.00**
EXPENDITURE		
SALARY & WAGES	21,600.00	21,600.00
ACCOUNTING CHARGES	–	–
AUDIT FEES	11,800.00	11,800.00
BANK CHARGES	649.00	649.00
EXCESS OF INCOME OVER EXPENDITURE FOR THE YEAR	4,02,074.00	5,29,283.00
TOTAL	**4,36,123.00**	**5,63,332.00**
INCOME BROUGHT DOWN AND ADJUSTED WITH LAST YEAR	4,02,074.00	5,29,283.00
BALANCE BROUGHT DOWN FROM LAST A/C (Credit)	(20,85,979.48)	(15,56,696.48)
BALANCE TAKEN TO BALANCE SHEET (Credit)	(24,88,053.48)	(20,85,979.48)

Place : Kolkata
Date : 13/09/2019

Signed in terms of our separate Report of even date.

For Ray & Ray
Chartered Accountants
Firm Regisration No 301072E

Sd/-
Abihijit Neogi
Partner
Membership No. 61380

Sd/-	Sd/-	Sd/-	Sd/-	Sd/-
Sukanta Chakraborty	Vikash Kumar	Achintya Mukherjee	Prof. Anup Kumar Misra	Prof. (Dr.) Uday Bandyopadhyay
Accountant	Audit & Finance Office	Accounts Officer	Registrar (O)	Director

COMPLIANCE REPORT

Compliance Report of Bose Institute on the Audit Observations for the Financial Year 2018-19

Sl. No	Audit Observation	Replies
1.	The Institute has accounted for expenses on cash basis in the financial statement which is contrary to the fundamental accounting assumptions as per AS 1 notified by the Institute of Chartered Accountants of India.	All the expenses are accounted for following accrual basis of accounting only in the few cases expenses are charged on cash basis in order to match with the receipt of Grant in Aid from Ministry of Science and Technology, department of Science and technology Govt of India.
2.	Intangible assets in the form of books and journals are not amortised over the licence period and are being carried forward and depreciated even after expiry of their licence period which is not in accordance with the requirement of AS 26 notified by the Institute of Chartered Accountants of India. *The amount of such expired licences are presently not ascertainable.*	From the current financial year Intangible assets in the form of books and journals will be amortised over the licence period as per the requirement of AS 26 notified by the Institute of Chartered Accountants of India.
3.	As reported by the management, fixed asset register was prepared upto 31st March 2017 and for the period upto 31st March 2019 is under process of finalisation which could not be verified by us during finalisation of annual accounts.	Up to date Fixed Asset Register will be provided to the Audit team during next Audit Session.
4.	Liabilities towards gratuity and leave encashment are not ascertained as per actuarial valuation and the same are accounted for on cash basis contrary to the requirement of AS 15 notified by the Institute of Chartered Accountants of India.	Pension and retirement benefit funds are received from the DST on the basis of budgeted provisions duly approved by the Finance Committee every year and also duly ratified by the council of Bose Institute, hence such provision is not followed.

5.	The institute does not have internal audit system commensurate with the size and nature of its activity resulting in poor internal financial control.	Institute has its own internal audit system ,however ,due to shortage of staff Scope of internal audit does not commensurate with the size of organization.DST also conduct Internal Audit of the Institute every year to review the financial transactions .
6.	The Institute could not reconcile accrued interest on fixed deposits as per books of accounts with that as per bank confirmation in few cases.	Reconciliation process of accrued interest on fixed deposits as per books of accounts with that as per bank confirmation has been initiated and as soon as it will be done, the same will be placed to the Statutory Auditor for verification.
7.	We could not verify old brought forward current assets and liabilities amounting to Rs. 484.96 lacs and Rs. 614.67 lacs respectively. Consequential impact on the year's revenue and the net current asset position as at the end of the year is not ascertainable.	Reconciliation process of the Old outstanding balances of Current Assets / Liabilities are initiated and will be produced to the statutory auditor for verification when fully reconciled after getting necessary approval of Finance Committee of the Institute.
8.	Asset acquired from development and modernisation fund amounting to Rs. 666.57 lacs has been held under 'Investment Under Earmarked Fund' and has not been capitalised thereby understating the fixed assets to that extent. Consequential impact on depreciation and current year's profitability is not ascertainable.	Preparation of Fixed Asset register of Bose Institute up to 2018-19 is in process. With the finalization of Fixed Asset register, asset acquired under "Institute Development and Modernization Fund" will be capitalized.
9.	We could not verify old brought forward capital work in progress amounting to Rs. 2.62 lacs which need immediate review and adjustments in the books of accounts. Consequential impact on the books of accounts is not ascertainable at this stage.	Reconciliation of the capital work in progress has been done except for Rs.2.62 lacs .Reconciliation status will be reported to the Statutory Auditor in next Financial year
10.	The Professional Tax Return is not reconciled with the books of accounts.	Reconciliation process is going on and will be reported to the Statutory Auditor.

134th Birthday Celebration of Prof. Debendra Mohan Bose

The **134th Birthday of Prof. Debendra Mohan Bose** was celebrated on November 26, 2018, at the Main Campus Lecture Hall of the Institute. **Prof. Somak Raychaudhury,** Director, Inter-University Centre for Astronomy & Astrophysics, Pune, graced the occasion as Guest of Honour and delivered the D. M. Bose Memorial Lecture on the topic **"Going to Space to Observe the Sky"**. Prof. S. C. Roy, Member, National Commission of History of Science and Editor-in-Chief, Science and Culture, ISNA, presided over the programme.

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