**Bose Institute**
**Kolkata**

**(An autonomous research institute of Dept. of Science & Technology, Govt. of India)**

**Advertisement No. : BI/NET-JRF/08/2022-23**

# Admission for PhD Programme
# Autumn 2022

Bose Institute, Kolkata is a Central Autonomous S&T Institute under Department of Science & Technology, Ministry of Science & Technology, Govt. of India, dedicated to research in Physical and Life Sciences. For details of various academic research activities, please visit Institute's website at http://www.jcbose.ac.in.

Acharya J. C. Bose, the founder of modern science in the Indian subcontinent, established Bose Institute in 1917. The Institute was set up as Asia's first interdisciplinary research centre and bears a century-old tradition of excellence in research.

The Institute desires to admit students for its Ph.D. programme twice a year, for sessions beginning tentatively in January and July. Interviews for this session will be held tentatively during early January 2023.

Areas of research: Environmental Sciences, Chemical Sciences, Life Sciences & Physical Sciences.

- Candidates are required to provide a **Statement of Purpose** (SOP), in prescribed format.

Fellowship: Admissible as per Govt. of India rules as provided by UGC/CSIR/DBT/DST/ICMR

**Total number of vacancy**: **33 (UR-16, OBC-8, SC-3, ST-3, EWS-3)**

**Age limit:** Below 28 years (relaxation of age is applicable as per Government of India rules).

**Eligibility for PhD Interview**:

(1) Candidates should have an award of JRF (CSIR-UGC JRF/ DBT-JRF/ ICMR-JRF/ DST- INSPIRE/ DBT-BINC or equivalent), whose last date of validity should not be earlier than **31st March, 2023**. If candidates, who are in the final year of their Master's degree programme **and** are in possession of an award of a JRF, are selected, they will have to submit their final degree certificate at the time of joining.

(2) Master's degree or equivalent in any of the following fields: Engineering/ Science/ Technology with at least 55 % of marks for general candidates, while 50% marks is necessary for SC/ST/OBC (non-creamy layer)/ differently-abled and other categories of candidates, as per UGC norms.

(3) DST-INSPIRE candidates can only be admitted provisionally. Confirmation of their admission to the PhD programme of Bose Institute is subject to the final award of INSPIRE fellowship by DST. If the candidate is finally not awarded the INSPIRE fellowship by DST, his/her provisional admission is liable to be cancelled by the Institute.

(4) Candidates who have qualified in GATE/ JEST/ JGEEBILS/ NET (LS) etc., but who do not have a valid award of JRF mentioned in (1) above, or equivalent, are **ineligible to apply**.

**Application Process:**

Interested candidates fulfilling required eligibility should apply online at the URL – http://www.jcbose.ac.in/applications/PHD-ADMISSION/

Deadline for online application: 23:59 Hrs. on December 18, 2022

An acknowledgement receipt will be generated following successful submission of the online application form. Candidates **should retain this receipt** for future reference. If called for the interview, candidates **must** produce this acknowledgement receipt. No candidate will be allowed to appear for the interview without this receipt.

For any difficulties pertaining to online application, please send email to: bosephdadmission@gmail.com

1. Names of the shortlisted candidates, along with the date and time of interview will be displayed on the Institute website
   - It should be noted that mere appearance on the shortlist does not imply admission
   - The interview will be conducted in offline mode. Online interview will be taken only if :
     (i) candidate's place of residence is beyond 100 km from the Unified Campus of Bose Institute (candidate must furnish proof of residence)
     (ii) Candidate will be appearing for an interview at another institution on the same date (candidate must furnish a copy of interview letter, which mentions the date of interview)

     In such cases candidate must submit request via email (bosephdadmission@gmail.com) **within two days of publication of interview schedule** on Bose Institute website.

2. A two-step screening process will be followed, with knowledge in core subject being assessed in the first step and suitability of the candidate for conducting scientific research at Bose Institute, along with finalization of Ph.D. guide-candidate matching, being assessed in the second step. At the time of application, candidates will be required to submit a Statement of Purpose, which will be used during the second round of screening
3. Eligibility criteria including upper age limit will be reckoned on the last date of submission of application.
4. Only shortlisted candidates will be intimated the date of interview at the respective email IDs. The list will also be available at www.jcbose.ac.in.
5. Before applying, the applicants should ensure that they posses at least the essential qualifications and other conditions specified in the advertisement. If a candidate is found not eligible, his/her candidature will be cancelled at any stage of interview process. (It may be noted that even if a candidate qualified in the interview and subsequently it is found that he/she does not fulfill the eligibility criteria, his/her candidature will be cancelled).
6. No TA/DA will be allowed for appearing for the interview
7. Specific instructions regarding the interview will be communicated to the shortlisted candidates
8. The final list of selected candidates will be displayed on the Institute website
9. The Institute Authority reserves the right to reject any or all applications without assigning any reason thereof
10. The candidates may keep a watch at Institute's website for any amendment.
11. No interim queries in any form whatsoever will be entertained.
12. Canvassing or bringing influence in any form will disqualify the candidature.
13. Age relaxation will be given to the eligible candidates as per Govt. of India guidelines.
14. Reservation rules as notified by UGC for reservation to SC/ST/OBC/EWS shall be applicable.

15. Caste Certificate shall be furnished by the respective candidate to claim reservation in SC/ST/OBC category.
16. Any candidate claiming to belong to the OBC shall furnish a certificate in the prescribed form signed by any of the specified authorities. No other certificate will be accepted. The caste certificate issuing authority should also certify that the candidate does not belong any of the Creamy Layers (format given in Bose Institute website).
17. All disputes shall come under the Kolkata jurisdiction.

**Important Dates:**

- Last Date for online application: 23:59 Hrs. on December 18, 2022.
- For all information to follow our website at www.jcbose.ac.in

# Annexure – I

## Areas of Research: Atmospheric Sciences

| Name of Faculty | Research Project | Desired Master's Background |
|---|---|---|
| Abhijit Chatterjee | **Title:** Physical properties of aerosols over different atmospheric environments in eastern India<br><br>**Description:** Atmospheric aerosols, especially ultrafine aerosols suspended in the atmosphere bear immense ability to perturb the climate through changes in several microphysical properties of atmosphere including clouds. Such physical properties like scattering and absorption, atmospheric electricity, cloud condensing ability etc depend on the atmospheric environments, demography, tropographical features etc. The proposed study would be conducted to explore and investigate the role of aerosols of different size and different chemical composition on such important physical properties in the context of regional climate change. The study would therefore be conducted over different atmospheric environments, e.g. high altitude stations, coastal as well as urban metropolis in eastern India. | Environmental Sciences/ Atmospheric Sciences |
| Sanat Kumar Das | **Title:** A Study on the impact of air pollution on Fog Forecasting<br><br>**Description:** Fog is an important extreme weather condition, having simultaneously a strong impact on the environment, navigation, agriculture, health and many more. Forecast of fog is thereby demanding but a big challenge for atmospheric scientists to reduce the error in the outputs of forecast models. This error comes due to lack of on-field observations, and insufficient studies of the aerosol impact on fog formation. We all know that aerosols are coming to the atmosphere from different types of human activities as well as natural sources. Present project is mainly on applied physics and math with computational programing. This problem focuses onidentifying the pathway of aerosols affecting maximum in fog formation by coupling on-field observations and computer simulations to forecast the fog events in India. | Physics/ Environmental Sciences/ Atmospheric Sciences/ Computer Science/ Statistics/ Mathematics |

## Areas of Research: Chemical Sciences

| Name of Faculty | Research Project | Desired Master's Background |
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| Anup Kumar Misra | **Title:** Chemical synthesis of bacterial cell wall oligosaccharides for their use in the preparation of anti-bacterial glycoconjugate derivatives<br><br>**Description:** 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.<br><br>Objective: Chemical synthesis of complex oligosaccharides corresponding to the cell wall of bacterial polysaccharides.<br>The project will be dealing with synthetic organic chemistry.<br>Desirable academic background of the student: M.Sc in Organic Chemistry | Chemistry |
| Anup Kumar Misra | **Title:** Design and synthesis of glycomimetics and carbohydrate derived biodynamic molecules<br><br>**Description:** Carbohydrates are the most abundant natural products. Besides their role in metabolism and as structural building blocks, they are fundamental constituents of every cell surface, where they are involved in vital cellular recognition processes. Carbohydrates are a relatively untapped source of new drugs and therefore offer exciting new therapeutic opportunities. Advances in the functional understanding of carbohydrate–protein interactions have enabled the development of a new class of small-molecule drugs, known as glycomimetics. Glycomimetics are chemical entities that mimic the biological essence of carbohydrates and behave as pharmacologically useful molecules. Common structural changes to carbohydrate structures include replacement of the ring oxygen or substitution of the glycosidic oxygen, with nitrogen, sulfur or carbon. Such substitutions are usually made to impart a degree of metabolic or biological stability into the | Chemistry |

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| | compounds being developed or to generate compounds that mimic transition-state structures from glycohydrolase reactions. Replacement of different monosaccharide moieties in the complex polysaccharide fragments with simple charged functionality can be useful in developing useful biological probes. Glycomimetics address the drawbacks of carbohydrate leads, namely their low activity and insufficient drug-like properties. Here, we will design and synthesize a variety of glycomimetics to evaluate their biological potential to develop possible therapeutics.<br><br>**Objective:** Chemical synthesis of glycomimetics and carbohydrate derived molecules of biological importance.<br><br>The project will be dealing with synthetic organic chemistry. Desirable academic background of the student: M.Sc. in Organic Chemistry | |
| Shubhra Ghosh Dastidar | **Title:** Chemistry, Classical Dynamics and GPU computing: Basic Principles to Drug Design<br><br>**Description:** Biomolecules are complex chemical systems, whose conformational changes, interactions with others follow fundamental principles of nature which could be understood using the language of Chemistry, with some help of classical dynamics and statistics. The advancement of computational methods have been increasing enabling the prediction of the real time behavior of the biomolecules using the help of computer simulations. The GPU based computing is the latest trend that has revolutionized the accessible timescale of the simulations. This project will exploit these methods to analyze the structure and dynamics of the kinases relevance in diseases like cancers and other inflammatory disease to lead to design drugs to combat the diseases. | Chemistry/ Life Sciences/ Biotechnology/ Biochemistry/ Biophysics/ Computer Science |

## Areas of Research: Life Sciences

| Name of Faculty | Research Project | Desired Master's Background |
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| Abhrajyoti Ghosh | **Title:** Deciphering the role of prefoldin in the substrate transfer during archaeal protein folding<br><br>**Description:** Heat shock proteins, also known as molecular chaperones, are ubiquitous groups of proteins, present in all three domains of life, that maintain protein homeostasis inside the cell. There are five major classes of heat shock proteins, namely Hsp100, Hsp90, Hsp70, Hsp60, and small heat shock proteins. Hyperthermophilic archaea possess a minimal heat shock repertoire comprising two small heat shock proteins (Hsp14 and Hap20), one prefoldin, and a group II chaperonin (Hsp60). It has been demonstrated that Hsp60 executes protein folding in archaeal cells in an ATP-dependent manner while sHsps act as the first line of | Biotechnology/ Microbiology / Biochemistry/ Biophysics |

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| | defense, capture aggregating substrate proteins under stress conditions and protect them from aggregate formation. However, how these captured substrate proteins get transferred to Hsp60 for refolding remains elusive until recently. One of the sHsps, Hsp14 has been recently shown to be capable of shuttling substrates to Hsp60 for further refolding. A number of studies have proposed that prefoldin also plays an important role in substrate shuttling to Hsp60. However, the substrate transfer mechanics involving prefoldin remains largely unknown. In the present research work, our aim is to employ biophysical, biochemical, and genetic approaches to understand the precise role of prefoldin in archaeal cells, particularly on substrate shuttling under stress conditions. | |
| Anupama Ghosh | **Title:** Evaluation of secreted proteases of *Ustilago maydis* as potential virulence factors<br><br>**Description:** Plant pathogenic fungi adopt a number of molecular strategies to evade host defense responses and establish infection. Among others a number of small secreted proteins (SSP) contribute significantly to these strategies and are therefore considered as important virulence factors. Although majority of the SSPs are hypothetical or putative proteins with no known structural or functional domains, many can be categorized into different classes of proteins with specific molecular functions. This project is aimed at studying the SSPs with protease activities that might contribute to the pathogenic mechanisms of *Ustilago maydis* and to decipher their contribution to the virulence strategies of the fungus. *U. maydis* is a basideomycete phytopathogen that causes smut disease in maize recognized by formation of tumors on different parts of the plants. Secreted proteases from different pathogenic fungi have been previously demonstrated to aid in the degradation of the cell wall components of the host plants. In addition some of the microbial proteases that end up into the host cell following secretion have been shown to interfere with the host defense signaling and facilitate infection by the microbe. In a recent study from our lab we have also shown involvement of a secreted aspartyl protease Ger1 in the sporulation and spore germination processes of *U. maydis*. However, there are many other ways a biotrophic fungal phytopathogen like *U. maydis* might utilize its arsenal of secreted proteases to gain control over the host plant and establish infection. This project will enable us to get detailed insights into some of these pathogenic mechanisms of *U. maydis* involving secreted proteases. The study will include experimental techniques involving cell biology, molecular biology, biochemistry, biophysics and genetics. | Life Sciences/ Biotechnology/ Microbiology/ Zoology/ Botany/ Biochemistry/ Biophysics |

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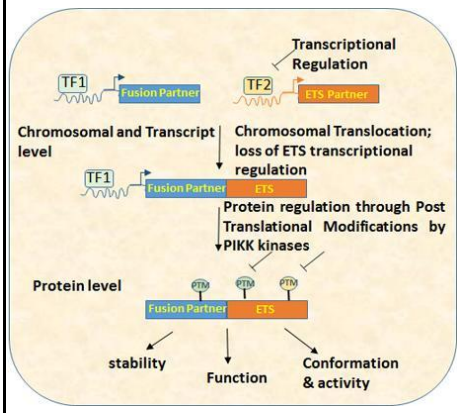
| Nirmalya Sen | **Title:** Regulation of ETS fusion transcription factors in refractory prostate cancer model<br><br>**Description:** ETS transcription factors are aberrantly over-expressed and mediate cancer progression through altered transcription of their target genes such as FLI1 in hematological malignancies, ERG in prostate cancer. Moreover, ETS factors generate oncogenic fusion genes through chromosomal translocation such as EWS-FLI1 fusion in Ewing sarcomas, TMPRSS2-ERG and TMPRSS2 ETV1 fusions in prostate cancer, which acts as drivers in these cancers. Due to generation of fusion genes, the transcriptional regulation of ETS partners undergoing such fusion events are often lost/deregulated making these fusions undruggable at transcriptional level (Model 1, below). We speculate that the regulatory post translational modifications of the ETS factors modulating their oncogenic functions might remain conserved and can serve as drug targets.<br><br>  <br><br><br>Our lab will be studying posttranslational modifications (PTMs like phosphorylation, ubiquitination, acetylation, etc) within the ETS proteins that are crucial for the stability and function of these protein and can provide excellent therapeutic targets even in the fusion counterpart**.** Currently, we are using prostate cancer to model our studies.<br><br>Most of our current studies will be based on two prostate cancer specific ETS fusion transcription factor regulation; namely ETV1 and ERG which are reported in ~80% of prostate cancer development. What roles ETV1 and ERG plays during development of castration resistance prostate cancer is not clear. We are using the latest molecular biological techniques ranging from mass spectroscopy to sequencing as well as mouse based studies to figure out the role of these ETS factors during progression of prostate cancer. The project tends to capture various aspects of hormone independent resistance prostate cancer including metabolic reprogramming, clinical intervention, DNA damage and drug resistance, patient derived models of prostate cancer in future.<br><br>*Objectives: i) Role of ERG and ETV1 fusion proteins in driving castration resistance prostate cancer, ii) To identify the mechanism of regulation of ERG and ETV1 fusion proteins in hormone independent prostate cancer***.** | Biotechnology/ Biochemistry/ Molecular Biology |

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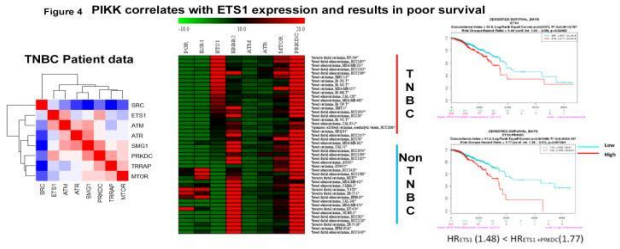
| Nirmalya Sen | **Title:** Role of ETS1 transcription factor in metastatic Triple negative breast cancer<br><br>**Description:** Recently, ETS1; a pioneering member of the ETS family, was shown to be associated with only Triple negative breast cancer (TNBC) but not the hormone dependent cancers. In fact the high expression of ETS1 is found only in hormone negative breast tumor cells but not in hormone susceptible ones which correlates negatively with patient survival (Figure 1). One of the most prevalent cancer in India women, TNBC tends to be resistant to hormone and chemotherapy, resulting in high mortality rates. The major pathology for the later stages of TNBC related complications is metastasis. A few studies have implicated ETS1 to be associated with breast cancer metastasis without clear mechanism. Pilot studies from my laboratory indicate ETS1 driven metastatic signatures in TNBC cell lines but not the hormone responsive lines. We also observed DNA repair kinases to be upregulated in TNBCs. I plan to study the breast to lung metastasis model for effective drug delivery using specific kinase inhibitors that target ETS1 expression.<br><br>  <br><br><br>*Objectives: i) Elucidate the mechanism of ETS1 regulation in triple negative breast cancer(TNBC) , ii) Role of ETS1during metastasis and angiogenesis with respect to DNA repair kinase inhibition in TNBC , iii) Study bilateral effects of DNA damage with respect to PIKK inhibitors in TNBC in vivo metastatic models* | Biotechnology/ Zoology/ Biochemistry/ Molecular Biology |
| Subhash Haldar | **Title:** Study the role of epigenetic changes in oncogenes induced by chemotherapy.<br><br>**Description:** Chemotherapeutic drugs modulate epigenetic factors involved in tumorigenesis. Tumor suppressor genes can become switched off in a somatically heritable fashion through epigenetic changes, in addition to the mutation of genes. Because of their dynamic nature and ready capacity for reversibility, epigenetic modifications are appealing therapeutic targets in cancer. Therefore, this is relevant to explore the epigenetic factors influencing inflammasome formation during tumor progression, metastasis, and in chemotherapy-resistant cancer. To find out different epigenetically silenced/activated genes involved in tumor progression, metastasis, and in chemotherapy-resistant cancer, it is pertinent to identify the epigenetically silenced /activated genes involved after and before the treatment with chemotherapeutic drugs and to check the mechanisms | Life Sciences/ Biotechnology/ Biochemistry/ Biophysics/ Physiology/ Molecular Biology |

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| | involved in such silencing/activation of genes expression. The methylation pattern of the identified genes needs to be analyzed by methylation-specific PCR, 5-MeC staining, and through bisulfite sequencing. It is also important to find out the factors (including DNMTs) and their role in the methylation of genes. Understanding the factors involved in epigenetic changes in both cell culture and mouse xenografts model will provide a therapeutic strategy against chemotherapy-resistant cancer. | |
| Subhash Haldar | **Title:** Role of NLRP3 inflammasome in chemotherapy resistant metastatic cancer.<br><br>**Description:** Inflammasome components and pathways may provide novel targets to treat inflammation and associated cancer. In the tumor microenvironment (TME), cancer cells secret many factors as a result of chemotherapeutic treatment, including IL-1β, IL-18 etc. through the activation of the inflammasome complex. Since these cytokines are pro-inflammatory in nature, they have also pro-tumorigenic effects. So, it would be important to examine the signalling pathways involved during cancer progression and therapy resistance in connection with inflammasome activation. To find out the involvement of inflammasome activation in cancer progression it is very important to check the expression and mechanism of activation of different factors in both benign and malignant cancer. Further, the pro-tumorigenic effect of inflammasome-secreted factors in TME needs to be examined. Cell lines from different cancer types which are common in Indian populations will be cultured and checked for inflammasome markers and their upstream factors in cultured cells treated with or without chemotherapeutic drugs. A mouse xenograft model will also be made to examine the tumor formation and targeting of inflammasome molecules for the treatment of cancer. | Life Sciences/ Biotechnology/ Biochemistry/ Biophysics/ Physiology/ Molecular Biology |
| Ajit Bikram Datta | **Title:** Understanding the molecular basis for the E2 specificity of the noncanonical ubiquitin E1, Uba6<br><br>**Description: A**ll higher vertebrates, unlike lower organisms such as yeast, code for two ubiquitin activating enzymes, referred as Uba1 and Uba6. Out of these two, Uba6 was discovered and characterized about a decade ago and is referred as the non-canonical E1. Uba6 is also unique amongst all UbL activating E1 enzymes due to the fact that it can activate two UbLs, Ubiquitin and FAT10. This non-canonical E1 transfers the activated ubiquitin to only a subset of E2s, some of which, but not all, are also capable of accepting ubiquitn from Uba1.<br><br>Interestingly, though the C-terminal Ufd domain of E1s is thought to impart their E2 specificity, swapping of the Ufd domain of Uba1 with that of Uba6 does not make Uba1 to transfer ubiquitin to Ube2Z, an Uba6 specific E2. This observation emphasized that other E1 domains apart from the Ufd also takes part in E2 recognition. To understand the | Chemistry/ Life Sciences/ Environmental Sciences/ Biotechnology/ Microbiology/ Biochemistry/ Biophysics/ |

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| | basis of this, we aim to utilize the recently published atomic resolution structure of Uba6 and carry out biochemical and mutational analyses on these protein as well as Uba1 to understand the basis of their E2 specificity. We further aim to understand the biological implications of these specificity altering mutations in cultured cell lines. | |
| Ajit Bikram Datta | **Title:** Understanding the residues that regulate the activity of Ubiquitin conjugating E2 enzymes upon "back-binding" of the allosteric ubiquitin<br><br>**Description:** Ubiquitin conjugating E2s share a common UBC fold domain that harbors the catalytic cysteine residue. Many of the E2s also harbor a second ubiquitin binding site distal to the active site that is referred as the "back binding site". It has been demonstrated that for a subset of E2s binding of this second ubiquitin molecule distal to the catalytic cysteine significantly enhances their catalytic efficiency though the precise molecular events behind this phenomenon is yet to be understood. We have serendipitously stumbled upon a few E2 residues that play an important role in determining the catalytic activity of an E2, most likely via the back-binding though many of these residues are away from either the catalytic or the or the backbinding site. This project shall involve biochemical studies on pinpointing the exact roles of these residues. | Chemistry/ Life Sciences/ Environmental Sciences/ Biotechnology/ Microbiology/ Biochemistry/ Biophysics |
| Shubho Chaudhuri | **Title:** Molecular characterization of factor(s) regulating transcription of MYB21 and MYB24 genes in Jasmonic acid signalling pathway during pollen development.<br><br>**Description:** We have investigated the role of plant specific HMG-box protein AtHMGB15 in pollen development. Our result indicated that athmgb15 mutant plants have defect pollen morphology and retarded pollen tube germination. Comparative transcriptomic study to decipher the role of AtHMGB15 in pollen development shows repression of JA biosynthesis and signalling in athmgb15 flowers. Further, preliminary analysis shows that AtHMGB15 acts as an transcriptional activator for the expression of two important master regulators of JA signalling, MYB21 and MYB24. MYBs are known to be the positive regulator of JA signalling for stamen and pollen development. However, JA signalling needs to be attenuated by regulating the transcriptional activity of MYBs. It is believed that additional stamen -specific factors plays an important role in regulating MYBs activity. Thus, it is important to characterize different components for transcriptional activation of MYBs during pollen development | Life Sciences/ Biotechnology/ Botany/ Biochemistry/ |

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| Shubho Chaudhuri | **Title:** Characterization of chilling stress response in rice landrace to identify the variant alleles using genomics and epigenomics approach.<br><br>**Description:** The high yielding indica varieties that are suitable for cultivation in India are devoid of cold tolerance traits. It is thus important to screen different rice landraces that may have novel gene pools, giving cold tolerance. With this objective, we have identified a cold tolerant rice variety called CB1, which is a boro germplasm collected from Hooghly district of West Bengal. The variety shows low levels of cold induced ROS production, electrolytic leakage and high germination rate post-cold stress, compared to the sensitive varieties IR36 and IR64. Moreover, higher expression levels of coldresponsive genes were observed in CB1 suggesting the presence of unique genetic and epigenetic regulation that might confer cold stress tolerance in the variety. In this proposal we intend to employ a multiomics approach for generating an in-depth map of the molecular events that regulate cold tolerance in CB1, at genetic and epigenetic levels. We will primarily focus on identifying the altered DNA methylation patterns in cold tolerant CB1 in the back drop of high yielding variety IR36 which is cold sensitive. | Life Sciences/ Biotechnology/ Botany/ Biochemistry/ |
| Srimonti Sarkar | **Title:** IDENTIFICATION OF THE MOLECULAR EVENTS THAT ENABLE DOUBLE DUTY OF CERTAIN GIARDIAL PROTEINS<br><br>**Description:** *Giardia lamblia* causes the widely-prevalent diarrheal disease giardiasis. This unicellular parasite has a small genome that is approximately 100x smaller than that of humans. Yet this small genome is not only capable of sustaining a zoonotic lifestyle involving two different morphological states, it also supports several complex cytoskeletal structures that are unique to this pathogen and allows it to coordinate the movements of four pairs of flagella and form a suction cup that enables attachment to the intestinal wall of the host. The small genome also produces the arsenal that *Giardia* uses to compete with the host gut microbiota. Previous studies in my laboratory have identified that certain proteins of *Giardia* perform tasks that are over and above to the well-characterized functions of such proteins discovered in other model organisms. This project aims to identify and characterize some of the regulatory mechanisms that enable certain giardial proteins to perform canonical as well as non-canonical cellular functions. It will involve characterization of the post-translational modifications of several target proteins and also identifying their cellular interacting partners. We will also study the change in the interaction profile of these proteins during various stress conditions. | Life Sciences/ Biotechnology/ Microbiology/ Zoology/ Botany/ Biochemistry/ Biophysics/ Genetics |

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| Shubhra Ghosh Dastidar | **Title:** Intercepting Kinase Allostery for Drug design: Computer simulations and machine learning<br><br>**Description:** Kinases have wide variety in terms of their involvement in specific cellular pathways and yet their common function, as a catalyst, is to bind ATP using their kinase domain and use it to phosphorylate a substrate that makes the progress of the cellular pathways possible. They are lucrative drug targets as the inhibition of specific kinase make halt the progress of a disease. Although in principle, this is a workable strategy, but in practice ATP competitive inhibitors often binds off target kinases too, as the ATP binding pocket is closely similar across all kinases. A better way out is to identify allosteric activation mechanism present in kinases and then intercept with inhibitors that would make the strategy kinase specific. The project would use high end GPU based computing to simulate the all atom dynamics of the kinases and then use machine learning methods to analyze to lead to the design of suitable small molecules as lead compounds. | Chemistry/ Life Sciences/ Biotechnology/ Microbiology/ Biochemistry/ Biophysics/ Computer Science |
| Soumen Roy | **Title:** Systems Biology of macromolecular interactions<br><br>**Description:** Most interactions defining molecular recognition and cell signaling are macromolecular in nature. Recently published and ongoing projects are in the areas of amino acid residue interaction networks, protein-protein interaction networks, protein-nucleic acid complexes, as well as protein-small molecule interactions. Here we strongly focus on the theoretical (mathematical and computational) aspects of intra-macromolecular and inter-macromolecular interactions. Validation of our theoretical predictions can be carried out through our experimental collaborators as well as in our own lab. If they wish, selected candidates are welcome to pursue this project in conjunction with other project/s of their choice conducted in our lab. | Chemistry/ Life Sciences/ Biotechnology/ Microbiology/ Zoology/ Biochemistry/ Biophysics/ Computer Science |
| Soumen Roy | **Title:** Competition, Cooperation, and Communication in microbes<br><br>**Description:** Recently published and ongoing projects in our lab are in the areas of: (1) phage-bacteria interactions and dynamics, and, (2) antimicrobial resistance. Our research is strongly guided by theoretical (mathematical and computational) investigations which can be validated by experimental studies conducted in our own lab as well as with collborators. The former includes but is not limited to network science, game theory, nonlinear dynamics, statistical physics, and information theory. If they wish, selected candidates are welcome to pursue this project in conjunction with other project/s of their choice conducted in our lab. | Chemistry/ Life Sciences/ Biotechnology/ Microbiology/ Zoology/ Biochemistry/ Biophysics/ Computer Science |

## Areas of Research: Physical Sciences

| Name of Faculty | Research Project | Desired Master's Background |
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| Saikat Biswas | **Title:** Research and development of Gas Electron Multiplier detector for the high-rate heavy ion experiment<br><br>**Description:** Micro Pattern Gaseous Detector (MPGD) is one of the best choices for the ongoing and upcoming high rate heavy-ion experiments because of its good rate handling capability and spatial resolution. The Gas Electron Multiplier (GEM) detector is one of the most advanced members of the MPGD group. The proposed project aims at the detailed investigation of the GEM detector which will include the understanding of the behaviour of the chamber under high irradiation (~ 10 MHz/cm2), the effect of the geometry of the chamber on its performance under high irradiation and also Monte Carlo based simulation studies to give an insight on the possible modification in the detector technology to improve its performance for the high rate heavy-ion experiments (e.g. FAIR in Germany). The work will consist of hardware activities and the development of a simulation framework for the GEM detector. As a part of a large collaboration, the student needs to collaborate in several experiments in India as well as abroad. | Physics/ Electronics |
| Saikat Biswas | **Title:** Research and development of Resistive Plate Chamber for the high-rate heavy ion experiment<br><br>**Description:** The Resistive Plate Chambers (RPC) are widely used in High Energy Physics (HEP) Experiments for timing and tracking purposes. With the ever-increasing requirement of high luminosity in heavy-ion experiments (e.g. FAIR in Germany, CERN at Switzerland), detectors with good rate handling capability are needed. The goal of the proposed project is to address the issues like limited rate handling (~ 10 kHz/cm2) capability of the RPC detector, effect of electrode materials on the rate handling capability of the detector, effect of gas mixtures and treatment of the electrodes (e.g. oil coating) on the performance of the chamber at higher rates. The work will consist of hardware and simulation of the RPC detector. As a part of a large collaboration, the student needs to participate actively in several experiments in India as well as abroad. | Physics/ Electronics |
| Saikat Biswas | **Title:** Research on gaseous detectors for imaging<br><br>**Description:** Several R&D on the societal application of the gas-filled detectors, developed for the High Energy Physics (HEP) experiments are ongoing across the globe. The proposed work is aimed to understand the possibility and applicability of gas-filled detectors such as Resistive Plate Chamber (RPC), Gas Electron Multiplier (GEM) etc as an imaging device. The work will require a dedicated | Physics/ Electronics |

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| | involvement for the hardware activities and in the development of the software framework. The R&D on the proposed project can be carried out at the operational detector laboratory at Bose Institute. The selected student will work mostly in the laboratory. | |
| Sanat Kumar Das | **Title:** A study on the role of aerosols on Himalayan glacier melting<br><br>**Description:** Earth's atmosphere is in thermal equilibrium state and maintains a constant temperature. However, in the recent era, atmospheric temperature is rising up, known as global warming due to the perturbation in Earth's radiation budget. Temperature rising is not uniform around the globe. A 'hot spot' region has been identified over the Himalayan region, which accelerates the glacier melting, indicating climate change over the Himalayas and alarming for future water crisis. Aerosols coming from different types of human activities have a major role in this hot-spot region. This project is very challenging because it is trying to solve an atmospheric problem using fundamental laws of physics. This study focuses on aerosol transportation, radiative heating effects, and establishing a link between atmospheric warming and Himalayan glacier melting. | Physics/ Environmental Sciences/ Atmospheric Sciences/ Computer Science/ Mathematics |
| Sidharth Kumar Prasad | **Title:** Understanding the dynamics of small collision systems<br><br>**Description:** One of the main goals of the relativistic nucleus-nucleus (A-A) collisions is to produce and characterize a system of strongly interacting deconfined quarks and gluons known as Quark Gluon Plasma (QGP). Protonproton (p-p) and proton-nucleus (p-A) collisions at same centre of mass energies are performed to provide a baseline measurements for making final conclusions about the QGP formation in A-A collisions. Conventionally formation of QGP is not expected in p-p and p-A collisions due to small achieved energy densities in these collisions. However, in recent experimental measurements, some of the observables in high multiplicity events for these collision systems are found to resemble features similar to that in A-A collisions hinting towards the possible formation of medium in these collisions. Some of the other observables related to the phenomena of jet quenching (one of the most important signatures of QGP) in contrary, do not show the effect of presence of medium in these collisions. Whether the QGP like effect seen in small collision systems is really a final state effect due to QGP formation or it is a manifestation of some initial state effects or both is not yet conclusive.<br><br>As a part of this research project we plan to investigate and study the particle production mechanism in small collision systems (p- p and p-A) at LHC energies by the measurements of hard probes and distributions of multiplicity, transverse momentum and energy of the produced particles in these collisions. | Physics |

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| Sidharth Kumar Prasad | **Title:** Study of relativistic nuclear collisions using photons<br>**Description:** At the Large Hadron Collider (LHC) at CERN two beams of heavy ions are made to collide at relativistic energies. A new form of matter of free quarks and gluons known as Quark-Gluon-Plasma (QGP) is produced in these collisions. One of the main goals of experiments at LHC is to study and characterize the properties of the produced matter. Both in theoretical and experimental fronts there are various observables that are defined using the properties of the produced particles in these collisions and used to characterize the QGP.<br>As a part of this research project we plan to explore and study the QGP properties using produced photons at high transverse momentum. | Physics |
| Achintya Singha | **Title:** Raman and Photoluminescence Spectroscopy of Two-Dimensional Materials and their Heterostructures<br>**Description:**<br>The broad interest of this project would be:<br>• To fabricate 2D layered materials with varying layer thickness and their heterostructures<br>• Probing vibrational and optical properties of the 2D materials and their heterostructures varying temperature, pressure and electric filed.<br>• Understanding fundamental of the quantum interactions in the 2D materials and their heterostructures | Physics |
| Achintya Singha | **Title:** Optoelectronics Properties of Two-Dimensional Materials and their Heterostructures<br>**Description:**<br>The broad interest of this project would be:<br>• To fabricate 2D layered materials and their heterostructures based optoelectronic devices<br>• Investigating optical and vibrational properties of the materials<br>• Study photo-response behavior<br>• Demonstrating spin-coupled valley photocurrent | Physics |
| Dhruba Gupta | **Title:** Breakup of the $^{9}$Li nucleus in the context of nuclear astrophysics<br>**Description:** Considerable attention has been paid to the possibility that the early universe might have been rather inhomogeneous, consisting of high-density proton rich regions along with low-density regions, which were comparatively neutron-rich. This was the natural consequence of neutron's longer mean free path, for which it could diffuse out of the high-density zones. Although D, $^{3}$He and $^{4}$He are produced in the observed relative abundances, there may also be non-negligible production of A > 12 isotopes. It is difficult to evaluate the merits of inhomogeneous nucleosynthesis versus standard big-bang | Physics |

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| | nucleosynthesis, because the rates of several important reactions are either not measured or not well established. For example, only few reactions involving $^{8}$Li have been measured and thus any conclusions regarding A > 6 nucleosynthesis must be regarded as tentative. Previous attempts to study the neutron capture $^{8}$Li(n, $\gamma$)$^{9}$Li reaction were mostly through (d,p) reaction with only a couple of experiments where direct (n, $\gamma$) was studied through Coulomb breakup. The main constraint in the previous measurements was low beam intensity and the difficulty to separate Coulomb and nuclear breakup contributions. In the proposed experiment we plan to separate these two contributions using low beam energy of 7 MeV/u and take advantage of higher $^{9}$Li beam intensity offered by HIE-ISOLDE at CERN. We plan to use the scattering chamber and SAND array at the third beamline of HIE-ISOLDE.<br><br>The successful candidate will be involved in all aspects of experiments namely, simulations, experimental design and setup, data analysis, and publication of scientific results. The candidate will also participate in other research endeavors of the group. We offer the opportunity to work in a stimulating environment on cutting edge research.<br><br>The PhD work may involve experimental activity in leading international research facilities like HIE-ISOLDE at CERN, Switzerland. | |
| Dhruba Gupta | **Title:** Breakup of the $^{7}$Be nucleus in the context of nuclear astrophysics<br><br>**Description:** Breakup reactions involving loosely bound nuclei are extensively used to study nuclear reactions and astrophysics. While stable nuclei having prominent cluster structures have been studied a lot, breakup studies of the radioactive nuclei have been very difficult due to the low beam intensities. The breakup nuclear reaction leads to a minimum three body final state with a broad continuum in the energy spectra. The reaction may occur as a direct breakup, or a sequential breakup through resonance states in the breakup continuum of the nuclei. Both Coulomb and nuclear forces can contribute to the breakup processes. Coulomb breakup reactions with a heavy target like $^{208}$Pb, are often used to derive information on the time reversed, astrophysically relevant, radiative capture reactions, whose direct measurements are almost impossible due to extremely low yield. We plan to study both the direct and sequential breakup of $^{7}$Be with $^{208}$Pb, over a wide angular range. The relative contribution of the direct and sequential breakup would throw light on the reaction dynamics as we move from stable to unstable nuclei. The breakup fragments detected at very forward angles would help in deriving astrophysical information in the context of the radiative capture reaction $^{3}$He + $^{4}$He $\rightarrow$ $^{7}$Be + $\gamma$. Monte Carlo simulations of proposed experiments would be carried out using the NPTool package, based on CERN | Physics |

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| | Root and Geant4 framework.<br><br>The successful candidate will be involved in all aspects of experiments namely, simulations, experimental design and setup, data analysis, and publication of scientific results. The candidate will also participate in other research endeavors of the group. We offer the opportunity to work in a stimulating environment on cutting edge research.<br><br>The PhD work may involve experimental activity in leading international research facilities like HIE-ISOLDE at CERN, Switzerland. | |
| Dhruba Gupta | **Title:** Coulomb dissociation of 14O in the context of the hot CNO cycle<br><br>**Description:** In nuclear astrophysics, the study of p + $^{13}$N radiative capture reaction is important in determining the transit from the Carbon-Nitrogen-Oxygen (CNO) cycle to the hot CNO cycle, occurring in supermassive stars, novae etc. In standard stellar atmosphere, the hydrogen burning in massive stars proceeds largely through CNO cycle. The observed $^{15}$N/$^{14}$N ratio is 100 times more than we calculate from the cold CNO cycle and the introduction of hot CNO cycle accounts for that deficiency. At the higher temperatures characteristic of explosive hydrogen burning in red giants and in novae and supernovae explosions, the $^{13}$N(p,γ)$^{14}$O reaction rate exceeds the temperature independent $^{13}$N (β+ν) $^{13}$C rate. This causes the conversion of CNO cycle to the hot CNO cycle, resulting in an increased energy production rate. The turning point is directly dependent on the cross section of the above radiative capture reaction and thus its rate and cross section is of significant interest. The measurement of direct reaction is difficult because of very low cross section. On the contrary, Coulomb dissociation of $^{14}$O to study this radiative capture reaction is an established method. However, to address the present discrepancies of 20-30% in both theoretical estimates and experimental data, new measurements with highly efficient detector systems like MUST2 are required. We propose to study Coulomb dissociation of $^{14}$O at 17 MeV/u with $^{208}$Pb target using MUST2 and VAMOS, at the GANIL rare isotope beam facility in France, to detect the protons and $^{13}$N respectively. We expect an order of magnitude improvement in the accuracy of the radiative width of the 5.173 MeV state of $^{14}$O. This would help to conclude if the hot CNO cycle may be ignited at lower densities to prevent collapse of supermassive stars. Monte Carlo simulations of the proposed experiment would be carried out using the NPTool package, based on CERN Root and Geant4 framework.<br><br>The successful candidate will be involved in all aspects of experiments namely, simulations, experimental design and setup, data analysis, and publication of scientific results. The candidate will also participate in other research | Physics |

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| | endeavors of the group. We offer the opportunity to work in a stimulating environment on cutting edge research. The PhD work may involve experimental activity in leading international research facilities like HIE-ISOLDE at CERN, Switzerland and GANIL, France. | |
| Suman Kumar Banik | **Title:** Fluctuations propagation in biochemical motifs<br><br>**Description:** Biochemical networks are made up of small recurring building blocks known as motifs. Repeated occurrence of these motifs plays a crucial role in signal propagation in networks of biological importance. Interactions among the components of a motif are probabilistic in nature generating fluctuations within the cellular environment. These fluctuations in turn give rise to phenotypic heterogeneity. Quantification of biochemical fluctuations is necessary to understand signal propagation in a stochastic environment. Our group focuses on the quantification of fluctuations propagation in model biochemical motifs in terms of different statistical measures, viz., variance, covariance, etc. The statistical measures are further used in understanding signal propagation from information-theoretic point of view. In order achieve the goal we use different tools of physics, chemistry and biology.<br><br>Reference:<br><br>1. A K Maity, P Chaudhury and S K Banik, Role of relaxation time scale in noisy signal transduction, PLOS One **10**, e0123242 (2015).<br>2. A Biswas and S K Banik, Redundancy in information transmission in a two-step cascade, Phys. Rev. E **93**, 052422 (2016).<br>3. M Nandi, S K Banik and P Chaudhury, Restricted information in a two-step cascade, Phys. Rev. E **100**, 032406 (2019).<br>4. Md S A Momin, A Biswas and S K Banik, Coherent feed-forward loop acts as an efficient information transmitting motif, Phys. Rev. E **101**, 022407 (2020). | Physics/ Chemistry/ Biophysics |
| Soumen Roy | **Title:** Quantum entanglement and Quantum information<br><br>**Description:** Quantum entanglement reexamines the concept of locality and reality in quantum mechanics. It allows non-local connections between two or more distant objects. This enables us to explore several useful information processing protocols such as quantum teleportation, quantum cryptography, quantum dense coding, etc. On the other hand, quantum information helps us in exploiting the principles of quantum mechanics in information processing. The study of quantum information is necessary for quantum computation and also in quantum communication. Though quantum entanglement can be implemented in various quantum algorithms, the effect of quantum entanglement in quantum information needs further scrutiny. We intend to study various problems in both quantum entanglement and quantum information | Physics/ Computer Science/ Electronics/ Mathematics, Statistics/ Engineering |

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| | separately and possibly in conjunction. Another aim is to study how entanglement influences the flow of information between quantum states towards the secure establishment of long-range quantum communication. If they wish, selected candidates are welcome to pursue this project in conjunction with other project/s of their choice conducted in our lab. | |
| Soumen Roy | **Title:** Interdisciplinary statistical physics: networks, games, economies, and living systems<br><br>**Description:** The interdisciplinary potential of statistical physics was foreseen over a century ago by Ludwig Boltzmann. Today, statistical physics is widely regarded as one of the most interdisciplinary areas in modern science. The following is a brief outline of recently published and ongoing projects in our lab. The projects mentioned here are merely representative and our interests extend much beyond.<br><br>We remain perennially interested in finding new measures to investigate the structure, function, and dynamics of complex networks as well as their innovative applications in diverse systems. Of late, we have scrutinized the effect of topology in evolutionary games on networks. Our recent interests include the physics of wealth distributions and econophysics.<br><br>A range of phenomena in life sciences ranging from the level of individual proteins to microbes are studied in the lab. These consist of purely independent theoretical studies involving techniques from physics, mathematics, and computational science. In addition, experiments are also carried out in our lab, which we try to model using theoretical techniques. If they wish, selected candidates are welcome to pursue this project in conjunction with other project/s of their choice conducted in our lab. | Physics/ Computer Science/ Electronics/ Mathematics, Statistics/ Engineering |