# Centre for Interdisciplinary Research in Basic Sciences (CIRBSc)

## Vision

**To establish a vibrant teaching and research Center comprising interdisciplinary area in Basic Science and Applied Life Sciences**

## Mission

- The mission of the Centre is to promote interdisciplinary research activities in the Basic Sciences and applied Life Sciences by employing necessary facilities, infrastructure and academic environment.
- To create a Challenging research opportunities to the students with a goal of preparing them to be a world class Scientist and responsible citizens.

## Introduction

This brochure introduces the research and teaching activities in the Centre for Interdisciplinary Research in Basic Sciences, which was established in 2006. The reason for its establishment was a realization of the fact that each modern development in biology has its roots in basic sciences. In order to achieve its goal the Centre has basic scientists as faculty members who are doing research in modern areas of life sciences. The Centre also has life scientists as faculty members who provide teaching and research support to the Centre. There are 14 faculty members; a few of them have received significant professional recognition with overseas links. Centre has 40 doctoral students. As a whole, the faculty published more than 150 publications in the last four years and pursuing externally funded research grants of Rs. 50 million. Being interdisciplinary research Centre our faculty are divided into self-selected research areas, which are the base for presentation in this brochure. In addition, our faculty is available for teaching other centres and departments on campus. The size of our research programme allows us to provide challenging research experiences for our students in the interdisciplinary fields in Basic Sciences focusing to biological sciences. Therefore, in addition to life scientists, the Centre is meant to provide opportunities for those who are trained in basic sciences (Chemistry, Computer Science, Mathematics, and Physics) and desire to pursue research in novel areas of life science.

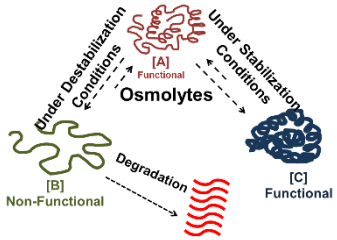
## The objectives of the Centre are:

- To promote interdisciplinary scientific research, advanced teaching and training in chosen areas of interdisciplinary Basic sciences and applied Life Sciences leading to M. Phil and PhD degrees;
- To provide a forum for intellectual interaction among Teachers, Scientists and Students;
- To provide best possible research facilities to those involved in Cutting Edge Science;
- To create Chairs for eminent Scientist/ Teachers for the promotion of academic and intellectual activities; and
- To promote interaction of students by conducting seminars, workshops, conferences and extension lectures on a regular basis.

## Protein Folding and Structure Biology

Protein folding is the physical process by which a polypeptide folds into its characteristic and functional three-dimensional structure from its unordered structure. Each protein exists as an unstructured polypeptide when translated from a sequence of mRNA to a linear chain of amino acids. Amino acid residues interact with each other and with solvent/co-solute molecules to produce a well-defined three dimensional structure, the folded protein, known as the native state. The resulting three-dimensional structure is determined by the amino acid sequence. For proteins the correct three dimensional structures is essential to function. Failure to fold into the intended shape usually produces inactive proteins with different properties including toxic prions. Several neurodegenerative and other diseases are believed to result from the accumulation of misfolded (incorrectly folded) proteins. The research in the Centre contributes powerful insights into protein folding science and their application in drug discovery. Following areas in the protein folding are investigated at the Centre.

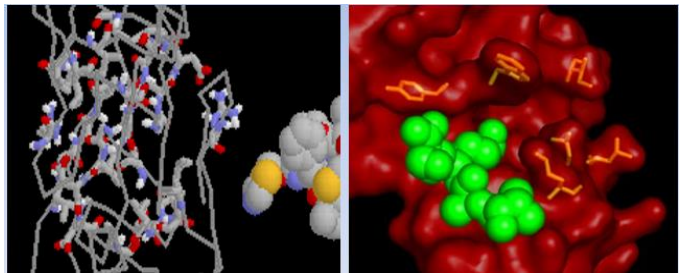
**Stabilization of Proteins by Osmolytes:** We have expertise in modulating stability of proteins and peptides using naturally occurring osmolytes (low molecular weight organic compounds). Thus, osmolytes can be used to stabilize and increase the shelf life of proteins and peptides (antibodies, hormones and therapeutic proteins).




**Protein Purification and Characterization:** Center has excellent facilities in protein purification and characterization.

**X-ray Crystallography:** Aim of research in this field is to investigate the relation between structure and function of biologically active macromolecules using the protein crystallographic techniques.

**Bioinformatics:** Biomathematics is a science that deals with the application of mathematical modelling methods and simulations to the

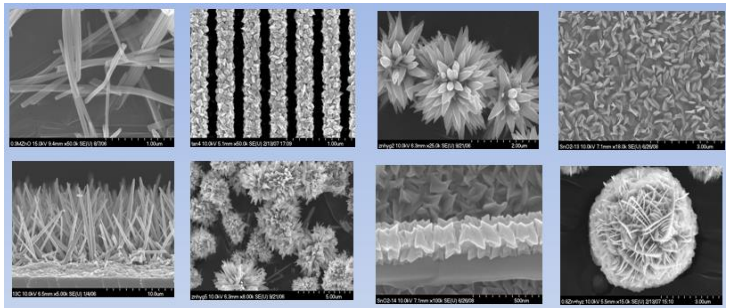


structure and functions of living organisms. The research in this field focuses on mathematical modelling of drug delivery systems and optimization of the devices based on i*n silico* analysis of protein structure and selection for drug target.

## Nanotechnology and Nanobiotechnology

When biomolecules/biocomposites are incorporated with nanotechnology, it is called nanobiotechnology. Centre has set facilities for research and development of nano-bioelectronics. This field is a rapidly progressing interdisciplinary research which combines physics, materials science, chemistry, microelectronics, computational methods and biotechnology. We focus to develop various biosensors using metal oxides (such as $TiO_2$, MgO, $SnO_2$ and ZnO) and bioreceptors as host materials for bio-molecule sensing via immobilization (cross-linked or covalently attached). Sensors are based on these materials are promising and proving to be far better than those conventional spectroscopic determinations. The key areas for research are utilization of nanostructured materials, immobilization capacities, fractal dimensional analyses, device characteristics from the commercialization point of view, etc.

Another important area in this category is the use of combination of nano- and bio- materials for efficient radiant and non radiant energy conversion. Focus is on to utilize nano-structured metal oxides and their composite for improving the present level of photo conversion efficiencies with inspired biomaterials.



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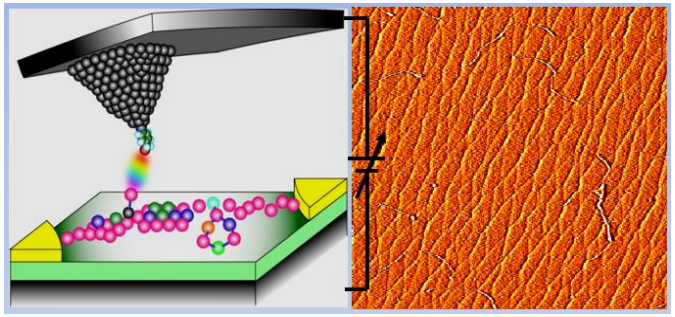
## Application of Scanning Probe Microscopy to Study Biomaterials

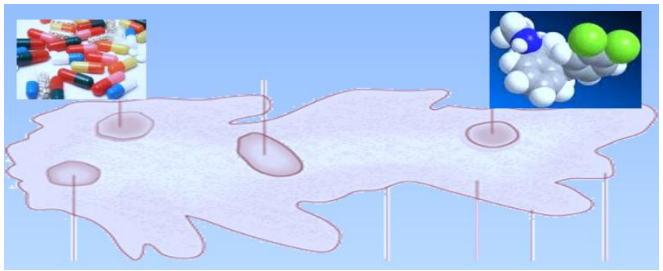
Scanning probe microscopy (SPM) is a group of microscopy techniques used to study the surface morphology, topological, structural and spectroscopic analyses at atomic and submolecular level. Molecule-molecule and atomic interactions on surface as well as with the scanning probe are studied using a physical probe that scans the specimen. An image of the surface is obtained by mechanically moving the probe on the specimen's surface in a raster mode, line by line scan of the specimen, line by line. The probe-surface interaction can be studied as a function of position. Recently, SPM is also utilized to manipulate, control and engineer the nanostructures on the surface including bio-molecules, in addition to the surface studies, quantum dot (QD) synthesis, sub-atomic layer deposition etc.

One of the fields of interest is the manipulation of biomolecules within designated regions on solid surfaces while preventing nonspecific adhesion at other regions; a basis of nano-patterning. Another field of interest is the use of semiconducting QDs as a fluore scence probe for biomolecules without any damage. Semiconductor QDs have good potential for use as fluorescent probes in biological staining and diagnostics. The ideal optical properties of QDs offer the possibility of using them to tag biomolecules in ultrasensitive biological detection based on optical coding technology.



## Medicinal Chemistry

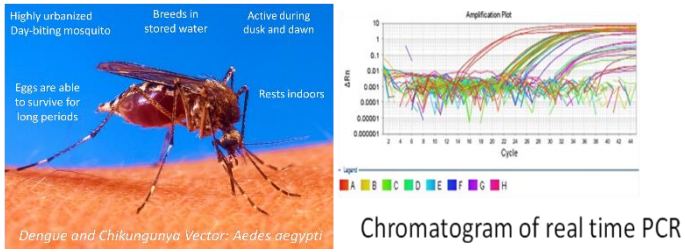
Medicinal chemistry is a discipline at the intersection of chemistry and medicine (pharmacology) involved with designing, synthesizing and developing pharmaceutical drugs. Medicinal chemistry involves the



identification, synthesis and development of new chemical entities suitable for t herapeutic use. It also includes the study of existing drugs, their biological properties, and their quantitative structure-activity relationships (QSAR). Pharmaceutical chemistry is focused on quality aspects of medicines and aims to assure fitness for the purpose of medicinal products. Centre has developed facilities and methods for the synthesis of compounds such as terpenes, triazines, sulfonamides, nucleic bases, porphyrins, dioxazoles and other novel organic entities. The developed molecules are utilised as probes, or as therapeutics (areas include antiprotozoal agents like antiamoebic agent). Nano-catalysts are also part of investigation along with extraction and isolation of compounds from plants.

## Molecular Biology of human viruses

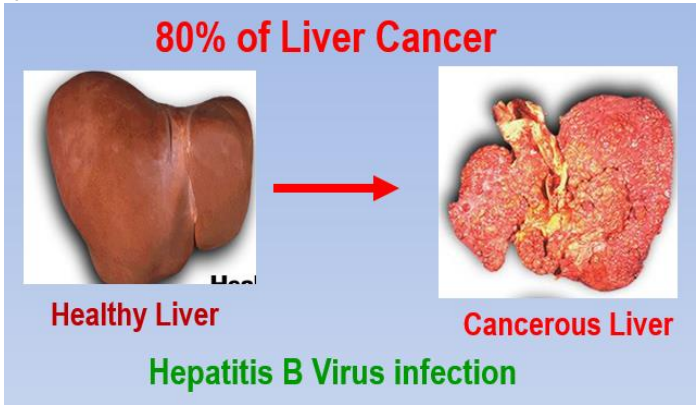
Dengue and Chikungunya fever are transmitted by *Ades* mosquito. In our laboratory diagnosis of these viral infections is being done in the clinical samples by RT-PCR. We are studying the evolution of these viruses by phylogenetic and Bayesian analysis. Surveillance and monitoring of Dengue and Chikungunya viruses (CHIKV) are important for the design




of strategies to control the impeding epidemics.

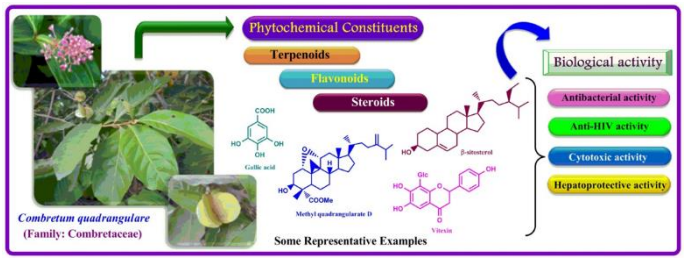
Respiratory viruses (respiratory syncytial virus (RSV) is major pathogen of acute respiratory tract infection (ARI) especially in children. We are working on detection of RSV in clinical samples using real time PCR. RSV evolution is being studied by phylogenetic and Bayesian analysis. The Centre is setting up facilities for RSV culture in different mammalian cell lines. Our research also focuses on cloning and expression of envelope proteins of CHIKV and RSV in mammalian and bacterial systems. Antigenic structural and biophysical characterization of different surface protein of human viruses will also be done which will help in vaccine development and drug designing.

Hepatitis B virus (HBV) is a member of the Hepadna virus family. HBV infection is a major cause of acute and chronic hepatitis, cirrhosis, and hepatocellular carcinoma (HCC). Two billion of the six billion people alive today show evidence of past or current infection with this virus and 350–400 million people are chronic carriers of HBV. The approved treatment options for CHB are mainly limited to interferon alpha and few nucleoside/nucleotide analogue(s). The later is reasonably effective in reducing the viral load but the prolonged usage in many cases generally becomes a potential threat in terms of emergence of antiviral resistant mutants. We have been working on molecular analysis of several types of hepatitis B virus mutations including the antiviral resistant mutants and on HBV genotypes, eventually have been able to unravel many novel aspects of viral mutations and their relevance in management of the liver disease. Moreover, our group has also contributed in the area of selection of antiviral therapy based on varying molecular biological, biochemical and histological profiles to treat HBV related chronic liver disease patients. Now, we are keenly interested in characterizing the novel and clinically significant viral mutations and in understanding the replication mechanisms of antiviral resistant constructs in *in vitro* cell culture based systems.




## Toxicology/ Molecular Reproduction

Successful ovulation and spermatogenesis involves the expression of various proteins at different stages in harmony with hormonal balance. Imbalance of these hormones can lead to over expression or under expression of crucial proteins involved in the process of ovulation and spermatogenesis leading to the failure of these processes. For the past few years we have been studying the toxicity of various plant products and chemical compounds that effect spermatogenesis, oogenesis, and hormone level in male and female reproductive system. We have been studying the expression and role of proteins that are expressed during

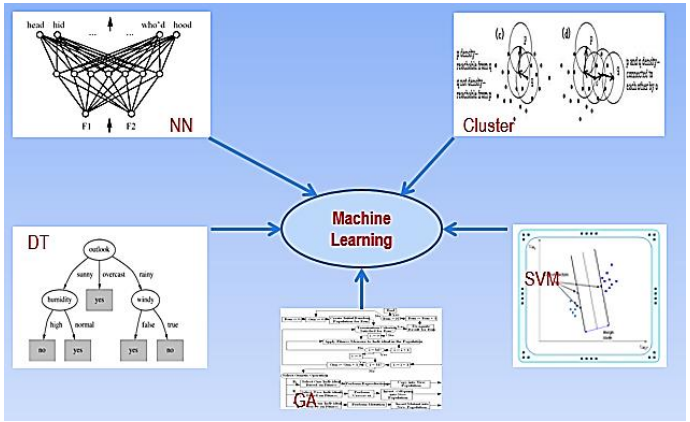



ovulation and spermatogenesis and are involved in reproduction. Pathways involved in the process of ovulation and spermatogenesis will be studied leading to the identification of various factors involved in these processes. An insight into the regulation of various proteins involved may open new vistas to understand the physiological role of

these proteins during these events. Furthermore, various other factors affecting reproductive parameters such as different stress conditions, environmental pollutants etc, which mimic hormones that lead to ovotoxicity and spermatotoxicity are part of investigations. Future work will also involve identification of various medicinal plant products or chemical compounds that can act as safe contraceptive.

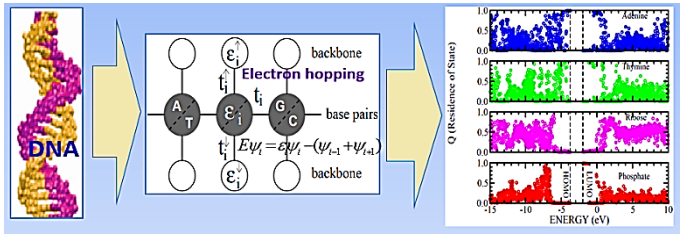
## Computational and Mathematical Biology

Machine learning is a long developed field in artificial-intelligence. Various bioinformatics problems and their trends and possible solutions can be obtained via machine learning technologies. Fuzzy logic and decision tree applications are useful for the analysis of biological data. The research interest would primarily involve the application of various machine learning tools and techniques in sequence analysis, drug designing, molecular interactions and drug protein interactions and function prediction etc.




## System Biology

In this field, a particularly emphasis is given to study the interaction between the components of biological systems. These interactions give rise to the unique features covering a wide range from understanding the animal kingdom for engineering purpose like strong beaks and powerful suckers in Jumbo Squid to drug release behavior in pharmaceutical industries to study the gelation behavior for food industries. We are interested in experimental, computational and mathematical modelling to simulate such interaction and their dynamics as well as kinetics behavior at single and bulk molecular level. We are also interested in the development of network and their topological characteristics (such as community, diameter etc.) from various data such as PPI, metabolic pathways and DNA microarray data.




## Interdisciplinary Research and Teaching

Interdisciplinary programmes are strongly encouraged in the CIRBSc. The faculty is involved in interdisciplinary research programmes with faculties from the other centres, various departments. Thus the Centre is meant to provide opportunities for those who are trained in basic sciences (Chemistry, Computer Science, Mathematics and Physics) and life sciences and desire to pursue research in novel interdisciplinary fields. A scholar registered in the Ph. D. programme of the Centre has to complete Pre-PhD course as per the UGC requirement. The students are also taught special courses for interdisciplinary techniques.

In addition to research activities, the Centre is running M. Phil. course in Interdisciplinary Basic Science with an intake capacity of 20 students. From the academic year 2015-16, the Centre has started a new course in M.Sc. Biophysics with an intake capacity of 20 students.

We make every effort to integrate our educational programmes into research programmes for both graduate and post-graduate students. The financial research grants brought by our faculty are important in supporting students. The research experience of our faculty is brought to the classroom, giving students a sense of the excitement and the cutting edge nature of the discipline.

We hope that through this brochure we have provided enough information about the aims and objectives of the Centre. A more current accounting of academic and research programs can be found at http://jmi.ac.in/cirbs

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