

Research Areas
Department of Biotechnology
Bhupat & Jyoti Mehta School of Biosciences
IIT Madras

BIOLOGICAL ENGINEERING (BE) STREAM

The focus of research in the Biological Engineering group is on two major areas: Bioprocess Engineering and Biomaterials Engineering

Bioprocess Engineering:

This group predominantly focuses on: Development of biomanufacturing platforms for (i) conversion of lignocellulosic biomass to value added products like ethanol, xylitol, arabitol, biopolymers and 3-hydroxypropionic acid; (ii) metabolic engineering strategies to improve the yields of industrially important metabolites; (iii) production of industrially important biocatalysts such as L-asparaginase, esterases, oxidoreductases and caffeine degrading enzymes; (iv) production of biopharmaceuticals and bioactive compounds from plants; (v) alternative food products (synthetic meat) and marine based bioproducts and (vi) understanding biological systems and its manipulation.

In all the above topics, a major focus will be on strain/cell-line development for the various products, including engineered strains using synthetic biology tools; development of process analytics for monitoring and control to ensure product quality and optimal yields; and development of integrated processes (including downstream processes) at lab-scale and validation at pilot-scale. Cell level strategies to improve bioprocess productivities, mainly reactive species-based ones; Reactive species-based strategies for treatment and management of diseases such as cancer and cardiovascular diseases

Biomaterials Engineering:

This group largely focuses on (i) Developing novel biomaterials for drug delivery and tissue regeneration; (ii) Designing bioengineered microenvironments to study physiological and pathological niches; (iii) Micro/Nanofabrication and 3D bioprinting technologies for the development of functional tissue scaffolds (iv) Engineering organoids and microfluidic tissue-on-a-chip platforms for disease modeling; (v) Extracellular matrix regulation to control cellular behavior (vi) Biochemical and biophysical stimulation for cells and tissues

This line of research is geared towards developing novel pharmaceutical agents, drug carriers, medical implants and drug-testing platforms for pharmaceutical companies, and clinical translation. In the future, we aim to develop therapies that modulate the immune system, musculoskeletal system, nervous system, cardiovascular system, and diseases like cancer, diabetes, amongst others.

COMPUTATIONAL BIOLOGY (CB) STREAM

The Computational Biology group focuses on diverse research areas which include (not limited to) the following topics:

- Protein structure and function; Protein stability; Protein interactions; Binding affinity; Transcriptome analysis; Disease-causing mutations; Development of databases and tools
- Molecular dynamics simulations of proteins and nucleotides; QSAR; Structure-based drug design
- Computational neuroscience
- Systems biology; Metabolic engineering
- Molecular evolution; Comparative genomics; Structural bioinformatics
- Protein assembly and aggregation; Design of drug delivery mechanisms

BIOCHEMISTRY AND MOLECULAR BIOPHYSICS (BMB) STREAM

This group is distinguished by a highly interdisciplinary nature of the research topics. Research compasses several areas of modern biochemistry and molecular biophysics, which include (but not limited to) the following topics:

- Protein Structure-Function Relationships; Structural Enzymology; Structural basis of Enzyme Properties; Protein Engineering; Structure and Mechanism of DNA Replication
- GPCR-mediated Signal Transduction; Biophysical chemistry of Calcium-binding proteins
- Biophysics; Green Chemistry; Structure-based Drug Design
- Phospholipid Scramblases; Membrane Biochemistry; Biochemical and Biophysical Characterization of Industrial Enzymes
- Structure-Function Relationships and Regulation of Ion Channels
- Protein Folding and Function; Protein-Protein and Protein-DNA Binding; Downhill Folding, Molten-Globules and Intrinsically Disordered Proteins; Thermodynamics, Dynamics and Kinetics; Liquid-Liquid Phase Separation; Engineering Protein Stability, Barriers and Rates; Statistical-Mechanical Models; Coarse-Grained and All-Atom Molecular Dynamics Simulations; Multi-Domain Proteins; Allostery; Dynamic Allostery; Epistasis; Macromolecular Crowding
- Enzyme-mediated Biomass Conversion for Biofuel and Functional Oligosaccharides; Bioremediation; Carbohydrate Chemistry
- Targeted Drug Delivery: Development of Conjugation Strategies for Antibody-Drug and Polymer-Drug Conjugates; Development of New Biosimilars: Identification of Novel Clones for Biosimilars and Improvement of Therapeutic Index of Proteins by Lipidation and Glycosylation; Biophysical Chemistry of modified Nucleic acids

In addition to conventional experimental biochemical approaches, combined with methods from molecular biology, recombinant DNA technology and microbiology, the techniques employed in the group include: Recombinant protein production and purification; X-ray crystallography; Bioinformatics analysis; Spectroscopy (Circular Dichroism, Fluorescence, Anisotropy, Fluorescence Life-Time, FRET, NMR and UV Absorption spectroscopy); Calorimetry (Differential Scanning Calorimetry, Isothermal Titration Calorimetry); Mass spectrometry; AUC; SAXS; Stopped-Flow Kinetics; Engineering Mutations in Proteins, Coarse-Grained and All-Atom Molecular Dynamics, Statistical Mechanical Models; Membrane protein overexpression and purification; Biochemical reconstitution of membrane proteins; in-vitro phospholipid translocation assays; Electrophysiology and Patch clamp; Calcium imaging; Ion-chromatography; Protein-protein interactions; Molecular dynamics simulations; Protein-ligand docking; Small molecule synthesis; Biological assays; Mammalian cell culture; Microscopy (Fluorescence, Scanning and Cryo-EM), among others.