DEPARTMENT OF BIO-ENGINEERING
BIT, MESRA

Area of Research

1. Biodiversity & Bioprospecting
2. Bioprocess modeling and simulation
3. Bioprocess Engineering
4. Bioinformatics
5. Biomedical Instrumentation
6. Biophysics
7. Computational Biology
8. Environmental Microbiology
9. Enzyme Technology
10. Fermentation Technology
11. Food & Agriculture Biotechnology
12. Microbial Biotechnology
13. Nanobiotechnology
14. Plant & Agriculture Biotechnology
15. Renewable Energy

Syllabus for 1st Group - Biotechnology

1. Molecular Biology and rDNA Technology

DNA structure & Chromosomes: DNA as genetic material, structure of DNA, DNA replication, repetitive DNA, Chromosomal DNA and its packaging,

Genetic organization: Discovery and salient features of genetic code, overlapping genes, organellar genetic code, colinearity of genes and protein.

Regulation of gene activity: Central dogma, difference in genetic organization of prokaryote and eukaryote, *lac* operon.

Mutation**:** General properties and types of mutation**,** DNA damage and repair, reverse and suppressor mutations, duplications, deletions, inversions and translocations, polyploidy, transposable elements, inborn errors of metabolism.

RNA & Protein**:** RNA synthesis & RNA processing, Protein synthesis, Posttranslational modifications**.**

Creation of Recombinant Molecules: Characteristics of plasmid and other cloning vectors, artificial chromosomes, prokaryotic and eukaryotic expression vectors, Recombinant Protein purification by IMAC method.

Genomic evolution: Forward and Reverse genetics

Methods in Genetic Engineering*:* Restriction and modifying enzymes, Southern blot, Northern blot, Western blot,

Polymerases, PCR technique, RACE PCR, RealTime PCR, Thermostable DNA

DNA sequencing**:** Sanger, NGS Whole Genome Sequencing: Strategies used

Post-Transcriptional Gene silencing**:** RNA interference, antisense RNA, siRNA, MiRNA,

Applications of Recombinant DNA Technology**:** Transgenic plants and animals, DNA vaccine, Gene therapy, PCR based diagnosis.

2. Bioprocess Engineering

Cell growth and bio-product formation kinetics**:** Quantification of cell growth, growth patterns and kinetics in batch culture, environmental factors affecting growth kinetics, kinetics of product formation.

Enzyme kinetics**:** Introduction to enzymes, mechanistic models for simple enzyme kinetics, rate parameters, effect of pH and temperature, methods of immobilization, diffusional limitations in immobilized enzyme systems, basic concepts of large scale enzyme production.

Media and air sterilization: Introduction and the kinetics of death, batch and continuous sterilization of media, air sterilization, various type of sterilization equipments, sterilization of media by membrane filters.

Agitation and aeration: Types of impellors and sparger, oxygen transfer rate, oxygen uptake rate, volumetric oxygen transfer rate (k_La), measurement of k_La, power requirement for agitation in gaseous and non gaseous systems.

Operating considerations for bioreactors**:** Choosing the cultivation methods, batch, fed-batch and continuous bioreactors

Analysis of ideal bioreactors: Fed-batch reactors, Enzyme catalysed reactions in CSTRs, CSTR reactors with recycle, Plug-flow reactor.

3. Microbiology

Methods in Microbiology: Microscopy, Methods of sterilization; culture media, Pure culture methods, Staining of Bacteria, Micrometry, culturing cells and spores, Classification of microorganisms into different groups: Bacteria, Viruses, Fungi, Actinomycetes, Outline of classification of bacteria and fungi

***Structure of Microorganisms and Microbial Metabolism*:** Fine structure of bacteria, Archaebacteria, Mycoplasmas, Mycobacteria, Myxobacteria, Rickettisae and chlamydiae, structure and classification of Viruses (Bacteriophage, Oncogenic viruses), Growth of Microorganisms, Cell cycles, Population growth, Batch culture, Continuous culture, Synchronous growth, Fed-batch culture.

***Environmental Microbiology*:** Distribution of Microbes in Air and water, Allergic disorders by air microflora, air sampling, Microbial components of water, Water treatment, Bacteriological analysis of water. Microbiology of Extreme environments (Methanogens, Halobacteria, Thermoacidophiles), Microbiology of sewage.

Agricultural Microbiology: Parasitism, Commensalism, Symbiosis and related microbial interactions, Rhizosphere and Rhizoplane, Bioinoculants. Beneficial plant-microbial interactions.Microbial Biodeterioration of agricultural products, Mycotoxins,

Microbial Biotechnology: Microbes in metal recovery, microbes in paper industries, Microbes as a source in vitamin production. Industrially important micro-organisms, secondary metabolites from micro-organisms.

Medical Microbiology: Diseases caused bacteria, virus, fungi, and protozoans; Fungal diseases (Mycoses), Microbial flora of healthy human host, host – microbe interactions, natural resistance and nonspecific defense mechanisms. Microbial agents of disease

4. ENZYME TECHNOLOGY

Introduction*:* Discovery, classifications (IUB enzyme classification) and nomenclature of enzymes. isozymes, multienzyme complex, and multifunctional enzymes, lock and key model and induced fit model apoenzyme, holoenzyme. Mechanism of enzyme action and activation energy, concept of active site, , enzyme turnover number specific activity, factors contributing catalytic efficiency of enzymes, enzyme isolation. enzyme assay, intracellular localization of enzymes.

***Enzyme kinetics and kinetics of enzyme inhibition*:** Competitive, non-competitive and un-competitive inhibition of enzymes. Michaelis- Menten equation double reciprocal plots. Effect of pH, temperature, substrate and enzyme and inhibitors concentration on enzyme kinetics. Phenomena of allosterism and allosteric kinetics.

***Molecular structure and function of enzymes*:** Physico-chemical characterization of enzymes. Folding and active site formation in enzymes. Stability of enzymes: Enzyme stabilization by selection and genetic engineering, protein engineering, reaction environment rebuilding. Mechanisms of Enzyme regulation in growth and product formation, techniques to overcome enzyme regulation, metabolic engineering,

***Techniques used in the purification of the enzymes*:** Criteria of enzyme homogeneity, Techniques used for determination of native and sub-unit molecular weight of enzymes. solid-liquid separation (filtration, centrifugation, membrane, flocculation), extraction, concentration (reverse osmosis, ultrafiltration), drying, instrumentation (GC/HPLC).

Enzyme immobilization: Various immobilization techniques, production and application of free and immobilized enzymes in food and feed, detergent, textiles, pulp and paper, pharmaceuticals, diagnostics and biotransformation of chiral drug and intermediate.

BIOMEDICAL INSTRUMENTATION

1) ELIGIBILITY CRITERIA

M. E. /M. Tech. in Biomedical / Computer / Electrical / Electronics / Instrumentation Engineering

or

M. Sc. / B. E. / B. Tech. in Biomedical/ Computer/ Electronics/ Instrumentation/ Physics

2) AREAS OF RESEARCH

- Biomedical Instrumentation
- Systems Biology
- Biomedical Signal Processing and Pattern Recognition

SYLLABUS FOR Ph.D. ENTRANCE EXAMINATION

Cell Structure and Functions

***Cell structure and Organization*:** Structure and Functions of Organelles, Cytoskeleton, Cell Membrane, Cell Division and Cycle.

***Fundamental of Genetics*:** Transcription and Translation; Biochemical Regulation of Gene Expression; Recombinant DNA Technology and Applications: PCR, DNA-Microarray; Principles of Mendelian Inheritance, Linkage, Recombination; Extrachromosomal Inheritance; Prokaryotic and Eukaryotic Genome Organization; Gene Mutation and Repair.

Anatomy and Physiology

Action Potential: Transport of Ions, Generation and Propagation of Action Potentials in Skeletal Muscle, Cardiac Muscle and Nerve Fibers.

Human Systems: Structure and Function of Human Circulatory, Respiratory, Digestive, Excretory, and Nervous Systems.

Computer and Microprocessor

***Computer Language*:** Assembly Language and High-level Languages, Multiprogramming and Time-sharing Operating Systems, Computer Programming in C.

***Introduction to Microprocessor*:** Organization & Simple Microcomputer System, Memory Units, Tri-state Switch; Architecture of 8085, Instruction Set, Addressing Modes and Addressing Format, Timing Diagram; Simple Assembly Language Programming, Data Transfer, Logic Operation; Interrupts & Peripheral Chips.

Electronics and Instrumentation

***Semiconductors*:** p-n Junction; Simple Rectifiers; Transistors, Characteristics of CB, CE, CC Amplifiers, Frequency Response; Introduction to Feedback Amplifiers; FET, Op-Amp and its Special Features.

***Definitions in Instrumentation*:** Accuracy, Sensitivity, Types of Error. Introduction to Galvanometer, PMMC Meter, D.C. Meter, Electronic Multimeter, Digital Voltmeter; AC & DC Bridges; Basics of CRO; Transducers & its Types: Resistive, strain gauge, capacitive, inductive, LVDT, photoelectric.

***Number systems*:** Binary Arithmetic, Boolean Algebra of Logic Gates. Simple Combinational Logic Circuits, Counters.

Biomedical Instrumentation

Biosignal Recording Devices: Sensors and Transducers in Biosignals Recording, Different Biosignals and their Acquisition System, EKG (ECG, EMG, EEG, EOG etc), Plethysmography, Blood Pressure, Spirometry and Pulmonary Function Test.

Biomedical Imaging Devices: X-ray, Ultrasound, CT-Scan and MRI.

Assistive and Therapeutic Devices: Pacemakers, Defibrillator, Diathermy, Nerve and Muscle Stimulator, Ventilators and Anesthesia Machine.