Department of Biotechnology
Bhupat and Jyoti Mehta School of Biosciences

Stream-wise syllabus for interview and written test for admissions to the MS and PhD programs

Biological Sciences (BS) Stream

Biochemistry:
Biomolecules, Principles of biophysical chemistry, Metabolism of carbohydrates, lipids, amino acids and nucleotides, Glycolysis, Oxidative phosphorylation, Coupled reaction, Mitochondrial electron transport, Enzyme Kinetics, Michaelis-Menten equation, Turnover number, Enzyme Inhibition, Mechanisms of Enzyme Catalysis.

Physiology:
Photosynthesis, Photo-protective mechanisms, CO2 fixation-C3, C4 and CAM pathways, Citric acid cycle, ATP synthesis, Nitrogen metabolism, Amino acid biosynthesis, Plant hormones, Solute transport and photo assimilate translocation, Blood circulation, Respiratory system and respiration, Sensory physiology, Sense organs, Excretion, Thermoregulation, Digestive system and digestion, Endocrinology, Stress and adaptation.

Molecular Cell Biology:
Membrane structure and function, Osmosis, Ion channels, Active transport, Ion pumps, Structural organization and function of intracellular organelles, Organization of genes and chromosomes, heterochromatin, euchromatin, and transposons, Cell division and cell cycle, Apoptosis, Cellular communication, Cell adhesion and roles of different adhesion molecules, Gap junctions, Extracellular matrix, Integrins, Neurotransmission, Cell surface receptor, Regulation of signaling pathways, MAPK pathway, Stress pathway, Cytokine pathway, Chemotaxis and quorum sensing.

Immunology:
Cells and molecules involved in innate and adaptive immunity, Antigens, Antibodies, Monoclonal and polyclonal antibodies, Complement pathway, Antigen-antibody interactions, Major histocompatibility complex (MHC) molecules, Antigen processing and presentation, B and T cells, Humoral and cell-mediated immune responses, Inflammation, Hypersensitivity, Autoimmunity, Graft versus host reaction, Immunization and vaccines.

Plant, Animal and Microbial biotechnology:
PLANTS: Totipotency, Regeneration of plants, Plant growth regulators and elicitors, Tissue culture and cell suspension culture system, Production of secondary metabolites, Plant products of industrial importance, Artificial seeds, Somaclonal variation, Protoplast fusion, Transgenic plants, Selection marker and reporter gene, Plastid transformation. ANIMALS: Culture media composition and growth conditions, Animal cell and tissue preservation, Kinetics of cell growth, Hybridoma technology, Stem cell technology, Animal cloning, Transgenic animals, Knock- out and knock-in animals. MICROBES: Production of biomass and primary/secondary metabolites, biofuels, bioplastics, industrial enzymes, antibiotics, Large scale production and purification of recombinant proteins and metabolites, Clinical-, food- and industrial- microbiology.

Molecular Genetics:

Mendelian principles, Alleles, Gene interactions, Linkage and crossing over, Construction of genetic maps, Evolution of gene concept; Extra chromosomal inheritance, Mutation, Structural and numerical alterations of chromosomes, Microbial genetics, Horizontal gene transfer and transposable elements, Population genetics, Epigenetics, Genetic drift, Species and speciation, Human genetics, Pedigree analysis, Karyotypes, Genetic disorders, Quantitative genetics, Polygenic inheritance

Gene Expression:
DNA replication, repair and recombination, DNA damage and repair mechanisms, RNA synthesis and processing, RNA editing, Splicing, Structure and function of different types of RNA, Protein synthesis and processing, Genetic code, Translational proof-reading, Translational inhibitors, Post- translational modification of proteins, Role of chaperons, Regulation of gene expression, DNA binding motifs.

Recombinant DNA technology and other tools in biotechnology:
Molecular cloning, Restriction endonucleases, Ligation, Gene transfer methods, Vectors, Agrobacterium mediated transformation colony hybridization, Plaque hybridization, cDNA and genomic DNA library, Transposons and gene targeting, Heterologous expression, Expression of recombinant proteins, In vitro mutagenesis and deletion techniques, Principle and applications of chromatography and electrophoresis, Centrifugation, Radiolabeling techniques, Fluorescent labeling, Polymerase chain reaction, DNA/RNA labelling and sequencing, Southern and northern blotting, In-situ hybridization, DNA fingerprinting, RAPD, RFLP, Site-directed mutagenesis, CRISPR-Cas, Microscopy, Spectroscopy, FT-IR, MS, NMR, Micro-arrays, Enzymatic assays, Immunoassays, Flow cytometry, Whole genome and ChIP sequencing.

Genomics and Proteomics:
Genomics and its types, Genome sequencing, EST, Polymorphisms, SNPs, Types of physicalmaps, Genomic databases, Homology sequence analysis, Gene Finding, Phylogenetics analysis, Metagenomics, Metabolic engineering and systems biology, Introduction to proteomics, Protein identification by peptide mass fingerprints, Peptide sequence analysis by tandem mass spectrometry

Biological Engineering (BE) Stream

Basic Mathematics:
Linear and quadratic equations, Matrices and determinants; Basic calculus, Ordinary differential equations; Mean, median, mode and standard deviation; Poisson, normal and binomial distributions

Fundamentals of Biological Engineering:
Material and energy balances for reactive and non-reactive systems; Stoichiometry of growth and product formation; Laws of thermodynamics; Solution thermodynamics; Newtonian and non-Newtonian fluids; fluid flow - laminar and turbulent; Molecular diffusion and film theory, mass transport under a concentration gradient, momentum transport under a velocity gradient, heat transport under a temperature gradient, charge flux under an electrical potential gradient, the above fluxes under simultaneous, multiple driving forces

Bioreaction Engineering:
Rate law; Ideal reactors - batch, mixed flow, and plug flow; Enzyme immobilization,

diffusion effects - Thiele modulus, effectiveness factor, Damkoehler number; Kinetics of cell growth, substrate utilization and product formation; Structured and unstructured models; Batch, fed-batch, and continuous processes; Microbial and enzyme reactors

Downstream Processing:
Filtration, Centrifugation, Cell disruption, Principles of chromatography: ion exchange, gel filtration, hydrophobic interaction, affinity, size exclusion; phase separation and extraction, adsorption, reverse osmosis, electrophoresis, separation and purification

Biomaterials Engineering:
Properties of biomaterials, biocompatibility, bioactivity, biodegradability; Material characterization; Basics of tissue engineering: scaffold fabrication, cell source, physicochemical and biological signals; Drug delivery: Conventional, controlled, sustained and targeted delivery, Mechanisms of drug release

Biochemistry and Molecular Biophysics (BMB) Stream

Basic chemistry:
Structure and Bonding: Ionic and covalent bonding, dipole moment, structure parameters such as bond length, bond angle and bond energy, hydrogen bonding and van der Waals interactions.

Reaction Kinetics: Rate constant, order of reaction, activation energy, zero, first and second order kinetics, catalysis and elementary enzyme reactions. Reversible and irreversible inhibition of enzymes.

Thermodynamics: First law, reversible and irreversible processes, internal energy, enthalpy, heat of reaction, heat of formation, Second law, entropy and free energy, Free energy change and spontaneity

Chemistry of Biomolecules: Amino acids, proteins, nucleic acids and nucleotides; Peptide and DNA sequencing by chemical and enzymatic proteolytic methods; Carbohydrates; Lipids; Principles of biomolecule purification; Identification of these biomolecules; Beer-Lambert's law.

Biochemistry:
Acids and bases; electronic and steric effects; Stereochemistry: optical and geometrical isomerism; tautomerism, conformers and concept of aromaticity.

Organization of life; Importance of water; Structure and function of biomolecules: Amino acids, Carbohydrates, Lipids; Proteins and Nucleic acids; Protein structure, folding/ misfolding and function; Structure and function of Myoglobin, Hemoglobin, Lysozyme, Ribonuclease A, Carboxypeptidase and Chymotrypsin.

Enzyme kinetics, regulation and inhibition; Michaelis-Menten equation, Mechanisms of enzyme catalysis; Bioenergetics and metabolism; Generation and utilization of ATP; Metabolic pathways and their regulation: glycolysis, TCA cycle, pentose phosphate pathway, oxidative phosphorylation, gluconeogenesis, glycogen and fatty acid metabolism; Metabolism of Nitrogen containing compounds: nitrogen fixation, amino acids and nucleotides. Photosynthesis, Calvin cycle.

Biochemical separation techniques: ion exchange, size exclusion and affinity chromatography, centrifugation; Characterization of biomolecules by electrophoresis; DNA-protein and protein- protein interactions; Principles of UV-visible and fluorescence spectroscopy; Mass spectrometry.

Cell structure and organelles; Biological membranes; Action potential; Transport across membranes; Membrane assembly and Protein targeting; Signal transduction; Receptor-ligand interaction; Hormones and neurotransmitters.

DNA replication, transcription and translation; DNA damage and repair; Recombinant DNA technology and applications: PCR, Site directed mutagenesis, Next generation sequencing; Gene silencing and editing, Types of mutation; UV and chemical mutagens; Selection of mutants; Bacterial genetic system: transformation, conjugation, transduction, recombination, plasmids, Regulation of gene expression: repression and induction; Operon model; Bacterial genome with special reference to *E. coli*; Phage λ and its life cycle

Microbiology and Microbial Diseases:
Culture techniques for isolation of microorganisms; Detection methods for microbial diagnosis; Light-, phase contrast-, fluorescence- and electron-microscopy, Growth curve and growth yields; Effect of environmental factors on growth; Antigens and antibodies; Human diseases caused by viruses, bacteria, and fungi, General characteristics of antimicrobial drugs; Antibiotics: Classification molecular mechanism of mode of action and resistance

Computational Biology (CB) Stream

Biological Macromolecules:
Proteins, nucleic acids; structural organization of proteins; Ramachandran plot; covalent and non-covalent interactions; protein secondary and tertiary structure prediction; molecular docking; thermodynamics; free energy, enthalpy, entropy

Sequence Analysis:
Mutations; PAM and BLOSUM matrices; local and globular alignment; algorithms; BLAST; multiple sequence alignment; conservation score; phylogenetic tree

Machine Learning techniques:
Supervised and unsupervised learning; linear regression technique; principle of least squares; neural networks; support vector machines; correlation; classification problems; assessment parameters; cross-validation procedures

Mathematics:
Geometry, Linear Algebra (matrices, planes, graphs), Probability and Statistics, Differential Calculus, integration

Computer Programming:
Coding in C/Python/Shell; algorithms, sorting