Centre for Life Sciences

Mahindra University

Global Thinkers. Engaged Leaders.

Syllabus for Ph.D. Entrance Examination
Streams: 1. Biotechnology; 2. Computational Biology

Ph.D. Biotechnology

1. **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.

2. **Cell and Molecular 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.

3. **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.

4. **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

5. **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.

6. **Genomics and Proteomics:** Genomics and its types, Genome sequencing, EST, Polymorphisms, SNPs, Types of physical maps, 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.

7. **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.

(or)

Biotechnology:

Plant Biotechnology: 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.

(or)

Animal Biotechnology: 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.

(or)

Microbial technology: 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.

8. **Techniques 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.

(or)

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

Ph.D. Computational Biology

1. **Biochemistry:** Biomolecules, Principles of biophysical chemistry, structural organization of proteins; Ramachandran plot; covalent and non-covalent interactions; protein secondary and tertiary structure prediction; molecular docking; thermodynamics; free energy, enthalpy, entropy, Enzyme Kinetics, Enzyme Inhibition.

2. **Cell and Molecular Biology:** Membrane structure and function, intracellular organelles, Organization of genes and chromosomes, heterochromatin, euchromatin, and transposons, Cell division and cell cycle, 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, Protein folding, Regulation of gene expression.

3. **Genomics and Proteomics:** Genomics and its types, Genome sequencing, EST, Polymorphisms, SNPs, Types of physical maps, 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.

4. **Bioinformatics:** Biological Databases: Accessing and querying biological data. Protein structure prediction, molecular modeling. Genomics: Genome assembly, gene prediction, genome annotation, Drug discovery, personalized medicine, systems biology.

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

6. **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.

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

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