

SCHOOL OF BIOTECHNOLOGY

Syllabus of Ph.D comprehensive Examination 2023-2024

(Part A comprises essential subjects that are mandatory for all students. Part B comprises various specialized subjects. Students can choose any one area of specialization from Part B.)

PART-A

Biochemistry: Biomolecules - structure and function (carbohydrates, (mono-, di-, and poly- saccharides), lipids, proteins (amino acids, peptides), and nucleic acids); Enzymes - Classification, Enzyme kinetics - Michaelis-Menten equation

Microbiology: Structure of Bacteria, virus, Fungi, Microbial interactions; Microbial growth and nutrition Cell Biology: Prokaryotic and eukaryotic cell structure; Cell cycle and cell growth control

Molecular Biology: Molecular structure of genes and chromosomes; Nucleic acid - replication, transcription, splicing, translation

Biostatistics: Mean, median, mode and standard deviation; Random variables; Correlation and regression analysis.

Recombinant DNA Technology: Restriction and modification enzymes; Vectors - plasmids, bacteriophage and other viral vectors, cosmids, Ti plasmid, bacterial and yeast artificial chromosomes; Expression vectors

Molecular Tools: Polymerase chain reaction; DNA sequencing; Southern and northern blotting; In-situ hybridization; DNA fingerprinting; Gene transfer technologies; CRISPR-Cas.

Analytical Tools: Principles of microscopy - light, electron, fluorescent and confocal; Principles of spectroscopy - UV, visible, CD, IR, fluorescence, FT-IR, MS, NMR; Electrophoresis; Microarrays;

Computational Tools: Bioinformatics resources and search tools; Sequence and structure databases; Sequence analysis

PART B

Cancer biology

Hallmarks of cancer cells, steps involved in tumor progression, proto-oncogenes, oncogenes, and tumor suppressor genes, benign and malignant-the genetic basis of cancer-Mutations and cancer- types of cancers-nature of cancer and classification-epigenetics of cancer-cancer stem cells-cell signaling in cancer-apoptosis, microbiome, and cancer, Infectious causes of cancer, virally induced carcinogenesis, tumor viruses, bacteria, and parasites causing cancer, molecular mechanisms linking infections, Epigenetics and cancer biology, non-coding RNA and Cancer biology, Epigenetic mechanisms, DNA methylation-histone modifications-chromatin remodelers and non-coding RNAs involved in epigenetic gene regulation, Techniques for epigenetic analysis and non-coding RNAs, Different techniques to analyze DNA methylation,-Chromatin analysis-methylation of RNA and non-coding RNA analysis. Engineered immune cells for cancer therapy. Breakage and Repair of Genomic DNA Clustered regularly interspaced short palindromic repeats (CRISPR)/Cas9 technology, nanotechnology for cancer treatment.

Microbial bioprospecting

Microbial growth principles, General concepts of value addition using microbial fermentation, Fermentation-types, Influencing factors, Fermentation monitoring, Fermentor design- parts and their functions, Strain improvement, Medium Optimization by response surface methodology and artificial neural network, Recent tools for pathway analysis, Downstream processing, Process technology for industrially important microbial products - baker's yeast, ethanol, acetone-butanol, organic acids, amino acids, polysaccharides, nucleosides and related compounds, enzymes, vitamins and antibiotics, Microbial transformations, Enzyme immobilization technology and its applications, Production of biomass, biofuels, biofertilizers, biopesticides, bioplastics and biosurfactants, and artificial flavors, Use of microbes for bioremediation, Waste water treatment using microbes, Bioleaching and metal extractions.

Immunology

Cells & organs of immune system: T & B-Cells, PMNs, NK cells, killer T-Cells, dendritic cells, bone marrow, thymus, spleen & lymph nodes, Types of immunity, Antigens & Antibody, their features, MHC, Complement system, Cytokines & their role in immune regulation. Immunotechniques: agglutination, precipitation, complement fixation, immunofluorescence, immunoelectrophoresis, ELISA, Widal test, VDRL test, immunoblot analysis. Immunohistochemistry, Immunoprecipitation, Immuno diffusion, RIA, FACS skin tests, immune complex tissue demonstration, Immune disease models. Methods used in immunology, Raising antibodies: by immunization, hybridoma techniques; Characterizing antibodies, Purifying antibodies, Preparing antibody fragments, Conjugating antibodies, Production of cellular cytokines, Development & use of vaccines, Antibody engineering, Catalytic antibodies. Inflammation, Chemotaxis, Immunity to viruses (HIV and Hepatitis), bacteria (Streptococci and Tuberculosis), fungi (Candidiasis), Autoimmunity and autoimmune disorder, Immunotherapy for cancer, HIV and autoimmune diseases.

Bioprocess Engineering and Technology

Basic principles in fermentation, General requirements of fermentation processes, Nutrient requirements, Design of various commercial media for industrial fermentations, Medium optimization using response surface methodology, Basic configuration of fermentor and ancillaries, Main parameters to be monitored and controlled in fermentation processes, Kinetics and stoichiometry of cell growth and product formation, Degrees of reduction of substrate and biomass, Electron balances, Yield coefficients of biomass and product formation, Maintenance coefficients, Energetic analysis of microbial growth and product formation, Oxygen consumption and heat evolution in aerobic cultures, Thermodynamic efficiency of growth, Mode of operation-Batch, fed batch and continuous cultivation, Introduction to structured models for growth and product formation, Simple unstructured kinetic models for microbial growth, Product formation kinetics, Leudeking-piret models, Substrate and product inhibition on cell growth and product formation, Mass transfer and determination of KLa, Study on the design of different bioreactors, packed bed, fluidized bed, airlift and plug flow reactors.

Plant Biotechnology

Gene transfer methods in plants, Gene expression assays by RNA transcript analysis, RNA interference and post-transcriptional gene silencing in plants, Marker-assisted seedling selection. Overview of secondary metabolism, Metabolic engineering of terpenes, alkaloids and phenolic compounds, Secondary metabolites in plant cell cultures, Properties and applications of hairy root cultures, Bioreactors for plant cell and tissue cultures. Molecular basis of biotic and abiotic stress, Transgenic crops for fungal, Bacterial and viral disease resistance, Herbicide resistance, Abiotic stress resistance, Gene pyramiding, Molecular farming for production of nutraceuticals, Improved nutritional quality through transgenic technology, Edible vaccines. Commercial status and public acceptance of transgenic plants, Biosafety guidelines, Socio economic impact and ecological considerations, Intellectual property rights in plant biotechnology.

Neuropathology and Applied Neurobiology

Cellular and Molecular Neurobiology: Neuronal structure and function.

Neurodevelopmental Disorders: Pathogenesis, molecular mechanisms, and diagnostic criteria.

Neurodegenerative Disorders: Amyloidopathies, tauopathies, synucleinopathies, and other protein aggregation diseases.

Neuroinflammatory Disorders: Immune responses, demyelination, and autoimmune conditions.

Neoplastic Disorders: Gliomas, meningiomas, metastatic tumors, and molecular classification.

Traumatic and Vascular Disorders: Head injury, stroke, and cerebral vascular malformations.

Molecular Basis of Neurological Therapies: Target identification, drug development, and personalized medicine.

Bioinformatics and Computational Biology

Important Biological Databases: Retrieving and analyzing data from biological databases, NCBI, Pubmed, RCSB-PDB, STRING, TCGA, GENECARD, PAM, BLOSUM, Gap penalties, pairwise sequence alignment using Dynamic Needleman-Wunsch, Smith-Waterman, and Heuristic programming algorithms, FASTA and BLAST, Common multiple alignment methods, CLUSTALX, Phylogenetic Analysis, Elements of phylogenetic models, Determining the substitution model tree, Evaluating phylogenetic trees, Protein sequence analysis, mass spectrometry (MS), Protein structure prediction, Homology Modeling-Biological Networks analysis using: major databases, representation, visualization and structural analysis, Regulatory Networks and Protein-protein interaction, Classification, and clustering of the biological data- Drug Design and discovery, Human Genome Sequencing, Next Generation Sequencing Methods, data generation and its Applications, assembly, Gene Predictions, and Annotation, Variant calling and analysis, GWAS studies, Microarray analysis, RNAseq analysis, Pathway analysis, and functional enrichment, Single-Cell Omics Data Analysis, Personalized Medicine-Metagenomics and Microbiome Analysis- Machine Learning in Bioinformatics: Supervised and unsupervised learning methods, Deep learning methods, Application of machine learning to bioinformatics problems, Interpretation and visualization of machine learning results