



Department of Post Graduate Studies and Research in Biotechnology

Syllabus for M. Phil. / Ph. D. Entrance Examination

UNIT - I

BIOCHEMISTRY

Chemical basis of life: Composition of living matter, properties of water, Ionization, Acids, Bases, pH, Buffers, Henderson - Hasselbalch's equation and its significance, Properties of Biomolecules, Covalent and Non-covalent interactions - Vander-Waals forces, Electrostatic interactions, Hydrogen bonding and Hydrophobic interactions.

Covalent structure of proteins: Amino acids - structure and functional group properties, peptides and proteins, study of primary, secondary, tertiary and quaternary structures of proteins; determination of primary structure of proteins. Forces stabilizing the structure of proteins. Structure - functional relationships in model proteins like myoglobin, hemoglobin, chymotrypsin.

Enzyme Catalysis: General principles of catalysis, characteristics of enzymes, classification and nomenclature of enzymes, co-enzymes. Activity and specific activity of enzymes. Michaelis - Menten kinetics, Enzyme inhibitions and regulations-allosteric and covalent modifications. Active site determination, Mechanism of action of enzymes - Chymotrypsin and RNase A.

Metabolism: Overview of metabolism, glycolytic pathway, Kreb's cycle and their regulation, elucidation of metabolic pathways, entry and exist of various metabolic intermediates from the central pathways. Oxidative phosphorylation - electron transport system, synthesis of ATP. Photosynthesis-C3, C4 and CAM pathways, Photorespiration.

UNIT - II

CELL AND DEVELOPMENTAL BIOLOGY.

Introduction to cell biology: levels of organization, Cell size and shape, Cell theory, cell as morphologic and functional unit within organism.

Endomembrane system: Ultra structure and functions of cell membrane, composition and dynamics transport of nutrients, ions and macromolecules (Pumps, carriers, channels, endo and exocytosis), cellular recognition, junctions and adhesions, structure and functional significance of plasmodesmata and organelles; endoplasmic reticulum, Golgi complex, lysosomes, microsomes, mitochondria, Mitochondrial DNA and male sterility, origin and evolution; chloroplast, chloroplast DNA and its significance, Chloroplast biogenesis

Cytoskeleton: microtubules and microfilaments; structure and functions of cilia and flagella; act in binding proteins, muscle organization and function

Cell cycle, cell aging and apoptosis; molecular events and regulation of cell cycle, molecular biology of cancer cell (carcinogenesis, benign and malignant tumors) cancer risk assessment; gene therapy and counseling, apoptosis, mechanism and significance.

Embryonic development; structure of gametes, cellular and biochemical processes during fertilization, strategies for monospermy and conservation of species specificity, cascade (acrosome reaction and egg activation cleavage blastulation, gastrulation) embryonic development. frog, morphogenetic movements origin of embryonic endoblasts (ecto, meso and endoderm), regeneration in animals with reference to hydra, planaria and salamander limb.
Biology of Oncogenes and Anti-Oncogenes

UNIT - III

MICROBIOLOGY & MICROBIAL BIOTECHNOLOGY

Microbial growth : The concept of growth and definition, formation of protoplasm, building of macromolecules from elemental nutrients, supramolecules, organelles of cell and cellular components. Cell cycle in microbes and generation time

Growth phases of bacteria: Lag phase, exponential (logarithmic) phase, stationary (ideo) phase, decline and survival of microbial cells. Importance of each growth phase.

Synchronous cultures: Methods of synchronous culturing Continuous culturing methods, factors effecting growth. Methods of growth measurement.

Microbes and Environment: Microbial interactions -microbe-microbe interactions, Plant microbe interactions, Biogeochemical cycles , Microbial communications system, quorum sensing Microbial fuel cells , Prebiotics and probiotics , vaccines.

Concepts of basic fermentation processes: Types of fermentations - Batch, Fed batch and continuous; Conventional fermentation v/s Biotransformation; Solid substrate, surface and submerged fermentation; upstream processing; Media formulation; Sterilization; Aeration and agitation in bioprocess; Measurement and control of bioprocess parameters; Scale up and scale down process. Strain improvement, Cell immobilization, culture preservation and inoculum development. Microbial culture selection, Microbial production of single cell oil, probiotics and other fermented foods

UNIT - IV

BIOSEPERATION & BIOANALYTICAL TECHNIQUES

Product Resolution/Fractionation - Chromatography: Gel filtration chromatography- effect of particle size, mobile phase flow rate, hydrostatic pressure, sample preparation, loading sample, molecular weight determination, spin columns. Equipment required for low pressure liquid.

Chromatography: Ion-exchange chromatography (IEC), Ion-exchange resins, Chromatofocusing, Molecular exclusion chromatography (MEC), Determination of MW by MEC, Hydroxyapatite chromatography, Affinity chromatography: Immunoaffinity purification, Immunoaffinity matrices, ligand affinity. Adsorptive chromatographic separations processes, hydrophobic interaction chromatography (HIC), RP - HPLC.

Radioactivity : Radioactive & stable isotopes; types and rate of radioactive decay; Units and Measurement of radioactivity; Geiger-Muller counter; Solid & Liquid scintillation counters (Basic principle, instrumentation & technique); Brief idea of radiation dosimetry; Cerenkov radiation; Autoradiography; Measurement of stable isotopes; Applications of isotopes; Isotope dilution technique; Clinical application - Radioimmunoassay

Advanced Techniques: Protein crystallization; Mass Spectrometry, MALDI-TOF, API-electro spray; Enzyme and cell immobilization techniques; protein sequencer, DNA & Peptide Synthesis, Method of detection and quantification of macromolecules on gels, staining procedures for proteins, nucleic acids etc. Zymograms, densitometric methods and Transilluminator.

IMMUNOLOGY & BIOINFORMATICS

Fundamental concept of immunology; types of immunity, phagocytosis, complement and inflammatory responses, haematopoiesis, organs and cells of the immune system primary and secondary lymphoid organs, lymphatic system, lymphocyte circulation and homing, mucosal and cutaneous associated lymphoid tissue.(MALT&CALT);Mucosal immunity; Antigens-immunogens , haptens, epitopes, factors that influence immunogenesis.

Immune responses generated by B and T lymphocytes; structure and function of immunoglobulins, organization and expression of immunoglobulin gene, immunoglobulin super family, B-cell maturation, activation and differentiation, memory cell, structure of B-cell receptors. T-cell maturation, activation and differentiation and T-cell receptors, functional T cell subsets, Cell mediated immune responses, Generation of antibody diversity.

Cytokines; structure, receptors, antagonists, related diseases and therapeutic uses, the complement system; functions, components, activation and regulation, effector responses, properties, CTLs, NK cells, ADCC delayed type hypersensitivity, macrophage activation, cell mediated cytotoxicity, Antigen processing and presentation-endogenous antigens, exogenous antigens, non-peptide bacterial antigens and super-antigens; cell-cell co-operation.,

Theories of antibody formation, Instructive, selective, clonal selection, organization and expression of immunoglobulin genes: structure, organization, Rearrangement, diversity, class switching, expression, regulation.

Clinical Immunology: Clinical Immunology ,Immunity to Infection : Bacteria, viral, fungal and parasitic infections (with examples from each group); Hypersensitivity – Type I-IV; Autoimmunity; Types of autoimmune diseases; Mechanism and role of CD4+ T cells; MHC and TCR in autoimmunity; Treatment of autoimmune diseases; Transplantation – Immunological basis of graft rejection; Clinical transplantation and immunosuppressive therapy; Tumor immunology – Tumor antigens; Immune response to tumors and tumor evasion of the immune system, Cancer immunotherapy; Immunodeficiency-Primary immunodeficiencies, Acquired or secondary immunodeficiencies.

BIOINFORMATICS

Databases and search tools: Database browsing and Data retrieval; Searching of databases similar sequence; The NCBI; Publicly available tools; Resources at EBI; Resources on the web; Database mining tools. Databases such as GeneBank; EMBL; DDBJ; Swissprot; PIR; MIPS; TIGR; Hovergen; TAIR; PlasmODB; ECDC; Searching for sequence database like FASTA and Blast algorithm. Biological background for sequence analysis; Identification of protein sequence from DNA sequence.

DNA sequence analysis: The gene bank sequence database; Submitting DNA sequence to the databases and database searching; Sequence alignment; Pair wise alignment techniques; Multiple sequence alignment; Flexible sequence similarity searching with the FAST3 program package; Use of CLUSTAL W and CLUSTAL X for the multiple sequence alignment; Where and how to submit, SEQUIN, genome centres; Submitting aligned set of sequences, Phylogenetic analysis, Primer designing and DNA microarray or Biochips

Growth phases of bacteria: Lag phase, exponential (logarithmic) phase, stationary (ideo) phase, decline and survival of microbial cells. Importance of each growth phase. Methods of synchronous culturing Continuous culturing methods, factors effecting growth. Methods of growth measurement.

Microbes and Environment: Microbial interactions -microbe-microbe interactions, Plant microbe interactions, Biogeochemical cycles , Microbial communications system, quorum sensing Microbial fuel cells , Prebiotics and probiotics , vaccines.

MOLECULAR BIOLOGY & GENETIC ENGINEERING

DNA Structure; Replication; Repair, Structure of DNA - A-,B-, Z- and triplex DNA; analysis of DNA structure; Replication initiation, elongation and termination in prokaryotes and eukaryotes; Enzymes and accessory proteins; Fidelity; Replication of single stranded circular DNA; Gene stability and DNA repair- enzymes; Photo reactivation; Nucleotide excision repair; Mismatch correction; SOS repair; Recombination: Homologous and non-homologous; Site specific recombination.

Prokaryotic & Eukaryotic Transcription: Prokaryotic Transcription; Promoters- Constitutive and Inducible; Operators; Regulatory elements; Initiation; Attenuation; Termination Rho-dependent and independent; Anti-termination; Transcriptional regulation-Positive and negative; Operon concept-lac, trp, ara, his, and gal operons; Eukaryotic transcription and regulation; RNA polymerase structure and assembly; RNA polymerase I, II, III; Eukaryotic promoters and enhancers; General Transcription factors; TATA binding proteins (TBP) and TBP associated factors (TAF); Activators and repressors.

Post Transcriptional Modifications: Transcriptional and post-transcriptional gene silencing, Processing of hnRNA, tRNA, rRNA; 5'-Cap formation; 3'-end processing and polyadenylation; Splicing; RNA editing; Nuclear export of mRNA; mRNA stability; Catalytic RNA.

Gene transfer in bacteria: History; Transduction - generalized and specialized; Conjugation - Hfr; F₁ transfer; Transformation - natural and artificial transformation; Replicative and non-replicative transposition.

Expression strategies and methods for producing industrially important molecules: Various expression vectors in bacteria and eukaryotes-Yeast, Baculovirus, Mammalian and Shuttle vectors. Induced expression strategies and protocols. Expression of industrially important products

Analytical techniques in Genetic engineering: PCR - design and optimization, Types of PCR-Inverse, Nested, Reverse Transcription-PCR, Hot Start PCR, Quantitative PCR use to engineer DNA, amplification of specific sequences from a cDNA library, use in diagnosis of diseases. DNA sequencing- Maxam-Gilbert method, Sanger's Dideoxy chain termination method, Automated DNA sequencing method. Human genome sequencing. Genetic and Physical mapping techniques.

Applications: Genetic diseases-Detection and Diagnosis, Gene therapy - ex vivo, in vivo, gene delivery systems, viral and non viral. DNA marker technology in plants, DNA fingerprinting, Genetically engineered biotherapeutics and vaccines and their manufacturing, Transgenic animals and Bio-pharming

Biosafety regulations: Biosafety - definitions - biosafety levels - framework of biosafety regulation in India; Structure and functions of Committees; DBT guidelines on biosafety in conducting research in biology / biotechnology. - Regulations of Genetically modified Organisms in India - Biosafety regulation for transgenic plants and animals - labeling of GM foods

UNIT - VII

ENVIRONMENTAL BIOTECHNOLOGY

Biomass and Bio-fuels: Plant biomass (Cellulose, starch, pectin, gum materials), Animal biomass (chitin, milk whey, Slaughter house wastes), Microbial biomass (algal blooms -in fresh and sea waters, Fungal- Mushrooms, yeasts and bacterial fermentation biomass wastes), Biodiesel from fatty oils. Concepts of single cell proteins, probiotics and their applications Biomass feed stocks to fermentations. Microbial production of fuels: alcohols, hydrogen and methane Microbial production of polymers (xanthan gums)

Bioremediation and Bio-leaching: Types and sources of pollution - Inorganic, organic and biotic. Clinical examples of air, water and land pollutions. Environmental impact of pollution and measurement methods. Composting of organic wastes, microbial bioremediation of oil spills. Waste water treatment - sewage treatment and common industrial effluent treatment. Concepts of bioremediation (in-situ and ex-situ), Bioremediation of toxic metal ions - biosorption and bioaccumulation principles. Concepts of phytoremediation. Microbial biotransformation of pesticides and xenobiotics. Microbial leaching of ores - direct and indirect mechanisms.

Biofertilizers and Biopesticides : Biofertilizers and their importance in crop productivity. Algal and fungal (mycorrhizae) biofertilizers. Bacterial biofertilizers (rhizobial, free living N₂ fixers and phosphate solubilizing bacteria), their significance and practice. **Biopesticides:** Bacterial (Bt pesticides), fungal (Trichoderma) Viral biopesticides - Baculovirus, NPV insecticides. Production of biofertilizers and biopesticides for large scale application.

UNIT - VIII

ANIMAL BIOTECHNOLOGY

Reproductive biotechnology; Anatomy of male reproductive systems, spermatogonia-stem cells, spermatogenesis, hormonal control of spermatogenesis, structure of sperm, morphology, anatomy and functions of male accessory reproductive organs, biology of semen and spermatozoa; Anatomy of female reproductive system, structure of ovary, folliculogenesis, follicular atresia, mechanism of ovulation (luteogenesis, luteinisation and luteolysis), Estrous cycle and its regulation, menstrual cycle and its hormonal regulation. In vitro fertilization, gamete intrafallopian transfer, surrogate pregnancy, artificial insemination, superovulation, cryopreservation of embryo, embryo transfer, embryo splitting, embryo sexing, micromanipulation of embryos.

Animal tissue culture; history of animal cell culture, advantages and limitations of cell culture, biology of cultured cell (cell adhesion, proliferation and differentiation), basic requirements for animal cell culture (design and lay out of cell culture room, equipment), culture media (properties), balanced salt solution, serum and serum free medium, primary culture, secondary culture, cell lines, stem cells, cloning cryopreservation, organotypic culture.

Culturing of specialized cells; cryopreservation, organotypic culture. Epithelial, mesenchymal, neuro, ectodermal, hematopoietic, gonad and tumour cells lymphocyte preparation, culture of amniocytes, stem cell culture, types characterization and its applications. Valuable products from cell culture, vaccines, recombinant proteins, monoclonal antibodies, hybrid antibodies, interferon, insulin, growth hormone.

Cloning, cloning vectors, expression vectors, animal viral vector and yeast vectors. Methodology of the transgenic animal production, examples of transgenic animals. Ethical issues in cloning and animal cell culture.

Sericulture: types of moth, Lifecycle and rearing methods of silk worm. Vermiculture; earthworms and their role in biodegradation of organic wastes. Techniques of vermiculture. Aquaculture; Fish and prawn culture methods, Application of Biotechnology in Seri, vermi and Aquaculture. Pest management by using hormones pheromones and genetic manipulation and baculoviruses.

Human Genome project and its applications, Types of genetic diseases targeted for gene therapy. Use of nucleic acid probes and antibodies in clinical diagnosis and tissue typing use of RAPD/RFLP and their applications.

UNIT -IX

PLANT AND AGRICULTURAL BIOTECHNOLOGY

Plant Tissue Culture: Historical perspective; Totipotency; Tissue culture media, Organogenesis; Somatic embryogenesis; Regulation and applications; Artificial seed production; Micropropagation; Somaclonal variation; Androgenesis and its applications in genetics and plant breeding; Germplasm, conservation and cryopreservation

Protoplast Culture and Somatic Hybridization: Protoplast isolation; Culture and usage; Somatic hybridization - methods and applications; Cybrids and somatic cell genetics.

Agro biology : Agro bacterium-plant interaction; Virulence; Ti and Ri plasmids; Opines and their significance; T-DNA transfer; Disarming the Ti plasmid.

Genetic Transformation : Agro bacterium-mediated gene delivery; Cointegrate and binary vectors and their utility; Direct gene transfer - PEG-mediated, electroporation, particle bombardment and alternative methods; Screenable and selectable markers; Characterization of transgenics; Chloroplast transformation; Marker-free methodologies; Gene targeting.

Molecular Mapping & Marker Assisted Selection (MAS) : Quantitative and qualitative traits; MAS for genes of agronomic importance, e.g. insect resistance, grain quality and grain yield; Molecular polymorphism, RFLP, RAPD, STS, AFLP, SNP markers; Construction of genetic and physical map; Gene mapping and cloning; QTL mapping and cloning. EST and substrative hybridization.

Strategies for Introducing Biotic and Abiotic Stress Resistance/Tolerance: Bacterial, Viral, Fungal, Insects and pathogens, Herbicide, Drought and salinity resistance. Examples: Bt Cotton/ Birinjal, Round up tomato, abiotic rice

UNIT -X

MEDICAL BIOTECHNOLOGY & NANO TECHNOLOGY

MEDICAL BIOTECHNOLOGY:

Microbial Diseases: Normal microbial flora of human body, host-microbe interactions. Infection and infectious process, routes of transmission of microbes in the body. Epidemiology, description and pathology of human diseases caused by bacteria; *Staphylococcus Streptococcus, Gonococcus, Enterobacteriaceae, E.coli, Salmonella, Pseudomonas, Klebsiella, Vibrio cholera;* pathogenic anaerobes, Tetanus, *Mycobacteria, syphilis, Chlamydae.*

Fungi: Description and pathology of diseases Caused by *Aspergillus Candida. Blastomycosis, Micrococcosis, Rhinosporeidial, Epidermophycosis.*

Protozoa: Malaria and Ameobiosis. Laboratory diagnosis of common infective syndromes and parasitic manifestations, Methods of transmission and role of vectors - biology of vectors. House fly, Mosquitoes, Sandfly. Need and significance of epidemiological studies

Molecular Virology - General Properties of viruses, Classification, medicinally important viruses, pathogenesis (HSV, HIV, and IMV), Host defenses, viral immunology, lab diagnosis and antiviral drugs., Structure, cultivation and replication of viruses.

Chemotherapy: Principles of chemotherapy, Mode of antibiotics: Penicillin, Streptomycin, Sulfonamides, and Polymyxins Antifungal drugs (Nystatin), Antiviral agents. Problems of drug resistance and drug sensitivity, Drug resistance in bacteria

Interferon - Nomenclature, types and classification. Induction of interferon, types of inducers. Inactivation of viruses - Photodynamic inactivation. Application of phages in therapeutic uses.

NANOTECHNOLOGY:

Synthesis of nanostructures: Natural in inorganic, Natural in organism, chemical and physical methods -Sol Process, Micelle, Chemical Precipitation, Hydrothermal Method, Pyrolysis, Bio-based Protocol, Chemical Vapor Deposition, Sputtering etc. Applications in various fields viz. Physical and Chemical, Materials, Life Sciences.