Ph. D Entrance Test Syllabus- Biotechnology

Amrapali University

Unit 1.Organization of structure and functions of prokaryotic and eukaryotic cells:

Cell wall and Cell Membrane: physical structure of model membranes in prokaryotes and eukaryotes, lipid bilayer, membrane proteins, other constituents; diffusion, osmosis, active transport, regulation of intracellular transport and electrical properties. Structural organization and functions of cell organelles: nucleus, mitochondria, Golgi bodies, endoplasmic reticulum, lysosomes, Chloroplast, peroxisomes, vacuoles. Cytoskeletons structure and motility function. Organization of genomes: genes and chromosomes, Operon, unique and repetitive DNA, interrupted genes, gene families, structure of chromatin and chromosomes, heterochromatin, euchromatin, transposons. Cell division and cell cycle: Mitosis and meiosis, their regulation, Cell cycle and its regulation, Apoptosis, Necrosis and Autophagy. Cell transformation and cancer, oncogenes and proto-oncogenes, tumor suppressor genes, metastasis. Therapeutic interventions of uncontrolled cell growth.

Unit 2. Biomolecular structure and function:

Covalent structure of Amino acids, proteins, nucleic acids, carbohydrates and lipids. Forces that stabilize biomolecules: electrostatic and van der Waal‟s interaction, hydrogen bonding. Interactions with solvents, Hydrophobic effect. Protein Structure: Structural characteristics of α-helix, β-sheet and β-turn. Ramachandran plot. Protein domains and domain architecture. Quaternary structure of proteins. Conformation of Nucleic acids: Structural characteristics of A, B and Z-DNA. 3D structure of t-RNA, ribozymes and riboswitches Basic Thermodynamics: Laws of thermodynamics. Concepts of ΔG, ΔH and ΔS. Physical properties of water and their role in biology. Concepts of pH, ionic strength and buffers. Chemical kinetics: Concepts of order and molecularity of a chemical reaction. Derivation of first and second order rate equation, measurement of rate constants. Concept of activation energy. Enzymology: Introduction to enzymes. Types of enzymatic reaction mechanisms, Michaelis-Menten kinetics. Competitive, Non-competitive and Un-competitive inhibition. Bi-substrate reaction kinetics. Allostery.

Unit 3. Cellular processes:

DNA replication, repair and recombination (Unit of replication, enzymes involved, replication origin and replication fork, fidelity of replication, extrachromosomal replicons, DNA damage and repair mechanisms, homologous and site-specific recombination). Transcription of various types of RNAs and their processing and modifications. Transcription factors and machinery including RNA polymerases, formation of initiation complex, elongation and termination of transcription. Regulation of transcription: activators (enhancers) and repressors, Locus control regions. Structure and function of different types of RNA and mRNPs. RNA transport, localization and function. Protein synthesis, processing and transport of proteins: Ribosome, mRNA structure, genetic code, aminoacylation of tRNA, aminoacyl tRNA synthetase. Mechanism of translation: Initiation, elongation and termination factors and translational proofreading. Regulation of Translation- global vs mRNA-specific. Translation inhibitors, Post- translational modifications of proteins. Protein trafficking and transport. Control of gene expression at transcription and translation level: Regulation of gene expression in viruses, prokaryotes and eukaryotes, role of chromatin, chromatin remodelling and gene silencing, Epigenetic regulation.

Unit 4. Genetics, Phylogeny & Evolution:

Chromosomal inheritance: Principles of Mendelian inheritance, codominance, incomplete dominance, gene interactions, pleiotropy, genomic imprinting, linkage and cross-over, sexlinked inheritance, Population Genetics and Hardy-Weinberg equilibrium. Extrachromosomal inheritance: Maternal inheritance (mitochondria and chloroplast) Gene concept: Allele, multiple alleles, pseudoalleles. Genetic analysis: Linkage maps, mapping with molecular markers, tetrad analysis, gene transfer in bacteria: transformation, conjugation, transduction, sex-duction, fine structure analysis of gene. Mutation: Spontaneous, induced, lethal, conditional, reversion, mutagenic suppression, germinal and somatic mutation, insertion, deletion, duplication, translocation, transposition, ploidy. DNA finger printing and its applications, DNA bar coding, marker assisted selection and QTL mapping. Species concept in archaea, bacteria and eukarya. Phylogenetic analysis and evolutionary relationship among taxa, MLST.

Unit 5. Techniques in Biotechnology

Concepts of precision and accuracy in experimental measurements. Concept of signal to noise ratio. Biostatistics: Measures of Central Tendency. Fundamental ideas of probability and probability distributions: Binomial, Poisson and Gaussian distributions. Concept of the Central Limit Theorem. Hypothesis testing: Use of Student‟s t and $\chi 2$ tests. Correlation and regression. Basic concepts of design of Experiments.

Biochemical Methods: Chromatography: Ion exchange, Gel Filtration and Affinity chromatography. Electrophoresis: Native and SDS-PAGE. Isoelectric focusing. 2D-PAGE and its applications. UV/Vis spectrophotometry. Beer-Lambert‟s law and its use in determination of protein/ nucleic acid concentration. Fluorescence Spectroscopy: Basic concepts of excitation and emission. Quenching, Stern-Volmer Plots. Theory and applications of FRET and fluorescence lifetime measurements. Fundamentals of CD, IR and Raman spectroscopy and their use in the study of biomolecular conformation. Centrifugation: Basic concepts of centrifugation. Calculation of g value from RPM. Density gradient centrifugation. Sedimentation velocity and Sedimentation equilibrium. Separation of sub-cellular components and macromolecules using high speed and ultracentrifugation. Microscopy: Bright field, phase contrast, fluorescence, confocal, and electron microscopy. Fundamentals of X-ray, NMR and cryo-electron microscopy for determination of biomolecular structure.

Unit 6. Recombinant DNA Technology:

Enzymes used in Recombinant DNA technology. Isolation and purification of DNA (genomic and plasmid) and RNA. Various methods of separation, characterization of nucleic acids including Southern and Northern hybridizations. Molecular cloning of DNA or RNA fragments in bacterial and eukaryotic systems. Expression of recombinant proteins using bacterial, animal and plant vectors and their purification. Western blotting. Generation of genomic and cDNA libraries. Plasmid, phage, cosmid, BAC and YAC vectors. In vitro mutagenesis and deletion techniques, gene knock out in bacterial and eukaryotic organisms. Isolation and amplification of specific nucleic acid sequences, PCR, RT PCR and qRT PCR. DNA sequencing methods, strategies for genome sequencing. Methods for analysis of gene expression at RNA and protein level, large scale expression, such as micro array based techniques. Analysis of DNA polymorphism: RFLP, RAPD and AFLP techniques.

Unit 7.Bioinformatics & Computational Biology:

Major Bioinformatics Resources: Sequence databases, Gene Expression database: GEO, SAGE, 3D Structure Database: PDB, NDB, Knowledge driven Databases & utility, Pattern Sequence: InterPro, Prosite, Pfam, ProDom, Gene Ontology Database Searches: Keyword-based searches using tools like ENTREZ and SRS Sequencebased searches: BLAST and FASTA Sequence Analysis, Basic concepts: Sequence similarity, identity and similarity, definitions of homologues, orthologues, paralogues, Tandem and Interspersed repeats, repeat finding. Scoring Matrix, Pairwise sequence alignments, Multiple sequence alignments (MSA), Application in Taxonomy and phylogeny, Comparative genomics. Structural Biology: 3-D structure visualization and simulation, Basic concepts in molecular modeling: different types of computer representations of molecules. External coordinates and Internal Coordinates, Molecular Mechanics, Force fields etc. Proteins: Secondary structure elucidation using Peptide bond, phi, psi and chi torsion angles, Ramachandran map, anatomy of proteins – Hierarchical organization

of protein structure –like CATH,SCOP, FSSP .DNA & RNA secondary and tertiary structures, t-RNA tertiary structure Classification and comparison of protein 3D structures: Secondary structure prediction:

Unit 8. Agricultural Biotechnology:

Tissue Culture, Transgenic Technologies and Biotechnology. Totipotency; Tissue culture media; Plant hormones and morphogenesis; embryogenesis; Cell suspension culture; Micropropagation – shoot tip culture, somatic embryos, artificial seeds; Applications of tissue culture; shoot tip culture; Wide hybridization, Anther culture and dihaploids. Production of alkaloids and other secondary metabolites; Protoplast isolation and purification; Protoplast culture; Protoplast fusion; Somatic hybrids; Cybrids. Direct transformation of protoplasts using PEG; electroporation; Transformation by particle bombardment; Chloroplast transformation. Ti plasmid-based transformation; Ti and Ri plasmids, T-DNA genes, borders, Ti plasmid virulence genes and their functions, Monocot transformation, binary vector; Floral dip transformation; Targeted gene delivery and methods of detection Promoters, Plant selectable markers; Reporter genes; Selectable marker elimination; Transgene silencing and strategies to avoid transgene silencing. Genetic engineering of crops; Codon optimization in the expression of genes in plants, Commercial status of transgenic plants; Herbicide resistance, glyphosate, sulfonyl urea, phosphinothricin, atrazine; Pest resistance, Bt toxin; Protease inhibitor; GNA and other lectins; a-amylase inhibitor; nematode resistance; Genetic engineering for male sterility-Barnase-Barstar; Delay of fruit ripening; polygalacturanase, ACC synthase, ACC oxidase; Improved seed storage proteins; Improving and altering the composition of starch and plant oils; Golden rice for ß-carotene accumulation; Production of antibodies and pharmaceuticals in plants. Biofuels, *Bacillus thuringiensis*: molecular basis of insecticidal activity. Agriculturally important microorganisms and their application.

Unit 9. Animal Biotechnology:

Immunology*:* Cells of immune system, clinical and transplantation immunology, tumor immunology and immunodeficiency. Nude and SCID mice biology and immunosuppression. Primary culture, secondary culture, sub-culturing, Cell lines, cloning & selection. Media, serum free media (advantage & disadvantages). Large scale culturing, Preservation and maintenance of anial cell lines. Cryopreservation, Cell culture products, Hybridoma technology. Gene transfer (transfection) methods, Embryonic stem cell transfer, In vitro fertilization and embryo transfer. Gene therapy, Animal cloning & ethical issues. Genetic diagnostic methods and microarray technology. Tissue and organ transplant, vaccines &peptide vaccines, Proteins as therapeutic agents, Applications, delivery and targeting of therapeutic proteins. Engineering human interferons and human growth hormones. Enzymes as therapeutic agents: Use of genetically engineered DNase I and alginate Lyase for treatment of Cystic Fibrosis.

Unit 10.Environmental Biotechnology:

Basic Ecological Concepts and Principles: Ecosystem: types, development and evolution; Homeostasis, energy transfer in ecosystem, Energy budget, trophic structure, food chain, food web, ecological efficiency, biogeochemical cycles Chemistry of organic and inorganic chemicals polluting Environment (air, water and soil). Environmental Pollution; Types, Detection and Measurement of Pollutants; Environmental monitoring techniques Water Pollution: sources, measurement and management;
5. Waste Water Treatment systems: primary, secondary and tertiary treatments; Biological Treatment Processes, Biochemistry and Microbiology of Aerobic and Anaerobic Treatment, Bioreactors for waste water treatment,,Disinfection and Disposal
6. Treatment of Typical Industrial Effluents: Dairy, Distillery, Sugar, and Antibiotic Industries.
7. Management of municipal, biomedical and agricultural solid waste.
8. Environmental Pollution control: concepts of bioaugmentation, biostimulation, biodegradation, biosorption, biofilms in the bioremediation of xenobiotics, petroleum hydrocarbons, pesticides and heavy metals, evolution of biodegradative pathways.
9. Environment friendly technologies: Biosurfactants, biofertilizers,biopesticides, microbially enhanced oil recovery, resource management, integrated waste management; production of biomass, biogas and biofuel from waste.
10. Pollution monitoring: chemical, biological and molecular methods; Environmental impact assessment, Biodiversity and its conservation, GMOs and Biosafety.
11.Global environmental problems: Ozone depletion, UV-B and green house gases