Syllabus for Ph.D. Entrance Test

Subject- Medical Biotechnology

Cell Biology:

a) 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.

b) Structural organization and functions of cell organelles: nucleus, mitochondria, Golgi bodies, endoplasmic reticulum, lysosomes, Chloroplast, peroxisomes, vacuoles. Cytoskeletons structure and motility function.

c) Organization of genomes: genes and chromosomes, Operon, unique and repetitive DNA, interrupted genes, gene families, structure of chromatin and chromosomes, heterochromatin, euchromatin, transposons.

d) Cell division and cell cycle: Mitosis and meiosis, their regulation, Cell cycle and its regulation, Apoptosis, Necrosis and Autophagy.

e) Cell transformation and cancer, oncogenes and proto-oncogenes, tumor suppressor genes, metastasis. Therapeutic interventions of uncontrolled cell growth.

Biochemistry:

a) Covalent structure of Amino acids, proteins, nucleic acids, carbohydrates and lipids.

b) Forces that stabilize biomolecules: electrostatic and van der Waal‟s interaction, hydrogen bonding. Interactions with solvents, Hydrophobic effect.

c) Protein Structure: Structural characteristics of α-helix, β-sheet and β-turn. Ramachandran plot. Protein domains and domain architecture. Quaternary structure of proteins.

d) Conformation of Nucleic acids: Structural characteristics of A, B and Z-DNA. 3D structure of t-RNA, ribozymes and riboswitches

e) Basic Thermodynamics: Laws of thermodynamics. Concepts of ΔG, ΔH and ΔS.

f) Physical properties of water and their role in biology. Concepts of pH, ionic strength and buffers.

g) Chemical kinetics: Concepts of order and molecularity of a chemical reaction. Derivation of first and second order rate equation, measurement of rate constants.

h) Concept of activation energy.

i) Enzymology: Introduction to enzymes. Types of enzymatic reaction mechanisms, Michaelis-Menten kinetics. Competitive, Non-competitive and Un-competitive inhibition. Bi-substrate reaction kinetics. Allostery.

Cellular processes:

a) DNA replication, repair and recombination (Unit of replication, enzymes involved, 2 replication origin and replication fork, fidelity of replication, extrachromosomal replicons, DNA damage and repair mechanisms, homologous and site-specific recombination).
b) 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.

c) 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 proof-reading. Regulation of Translation- global vs mRNA-specific. Translation inhibitors, Post- translational modifications of proteins. Protein trafficking and transport.

d) 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.

Genetics, Phylogeny & Evolution:

a) Chromosomal inheritance: Principles of Mendelian inheritance, codominance, incomplete dominance, gene interactions, pleiotropy, genomic imprinting, linkage and cross-over, sex-linked inheritance, Population Genetics and Hardy-Weinberg equilibrium.

b) Extrachromosomal inheritance: Maternal inheritance (mitochondria and chloroplast)

c) Gene concept: Allele, multiple alleles, pseudo alleles.

d) Genetic analysis: Linkage maps, mapping with molecular markers, tetrad analysis, gene transfer in bacteria: transformation, conjugation, transduction, sex-duction, fine structure analysis of gene.

e) Mutation: Spontaneous, induced, lethal, conditional, reversion, mutagenic suppression, germinal and somatic mutation, insertion, deletion, duplication, translocation, transposition, ploidy.

f) DNA finger printing and its applications, DNA bar coding, marker assisted selection and QTL mapping.

g) Species concept in archaea, bacteria and eukaryotes.

h) Phylogenetic analysis and evolutionary relationship among taxa, MLST.

Techniques in Biotechnology

a) Concepts of precision and accuracy in experimental measurements. Concept of signal to noise ratio.

b) 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.

c) Biochemical Methods: Chromatography: Ion exchange, Gel Filtration and Affinity chromatography. Electrophoresis: Native and SDS-PAGE. Isoelectric focusing. 2D-PAGE and its applications.

d) UV/Vis spectrophotometry. Beer-Lambert‟s law and its use in determination of protein/ nucleic acid concentration.

e) Fluorescence Spectroscopy: Basic concepts of excitation and emission. Quenching, Stern-Volmer Plots. Theory and applications of FRET and fluorescence lifetime measurements.

f) Fundamentals of CD, IR and Raman spectroscopy and their use in the study of biomolecular conformation.

g) 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.

h) Microscopy: Bright field, phase contrast, fluorescence, confocal, and electron microscopy.

i) Fundamentals of X-ray, NMR and cryo-electron microscopy for determination of biomolecular structure.

Recombinant DNA Technology:

a) Enzymes used in Recombinant DNA technology.

b) Isolation and purification of DNA (genomic and plasmid) and RNA. Various methods of separation, characterization of nucleic acids including Southern and Northern hybridizations.

c) 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.

d)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.

e) Isolation and amplification of specific nucleic acid sequences, PCR, RT PCR and qRT PCR

f) DNA sequencing methods, strategies for genome sequencing.

g) Methods for analysis of gene expression at RNA and protein level, large scale expression, such as micro array-based techniques.

h) Analysis of DNA polymorphism: RFLP, RAPD and AFLP techniques.

Immunology

a) Immune cells, B cells and antibodies
b) Immunoglobulin genes, Monoclonal antibodies, Antibody engineering
c) T cell receptors, Complement-system, Toll-like receptors, Cell-mediated effector functions
d) Inflammation, Hypersensitivity and autoimmunity
e) Congenital and acquired immunodeficiencies
f) Vaccines, Immunotherapy
g) Immunological techniques: ELISA, RIA, Immunoprecipitation.

Microbiology

a) Microbial taxonomy and diversity (bacteria, fungi, virus, etc.)
b) Microbial nutrition, growth and control
c) Microbial metabolism; Microbial genetics
d) Microbial production and purification of fermented food and food products
e) Recombinant proteins
f) Industrial enzymes; Free and immobilized enzyme kinetics
g) Types of bioreactors
h) Bio-separation techniques.