

PH.D. ENTRANCE EXAMINATION SYLLABUS FOR
MOLECULAR BIOLOGY-2011

UNIT 1: BASIC BIOLOGY

UNIT 2: MOLECULES OF LIFE, METABOLISM

UNIT 3: BIOCHEMICAL TECHNIQUES, ENZYMOLOGY

UNIT 4: MOLECULAR PHYSIOLOGY

UNIT 5: MOLECULAR CELL BIOLOGY, IMMUNOLOGY

**UNIT 6: MOLECULAR GENETICS, MOLECULAR BASIS OF
DEVELOPMENT AND DIFFERENTIATION**

UNIT 7: MOLECULAR PATHOLOGY AND SIGNAL TRANSDUCTION

UNIT 8: GENE EXPRESSION

UNIT 9: GENETIC ENGINEERING

UNIT 10: GENOMICS AND PROTEOMICS

UNIT 1: BASIC BIOLOGY:

i. Classification: Principles of classification, ICBN rules, Binomial and trinomial nomenclature, Whittaker's five kingdom concept

ii. Plant Biodiversity: Classification and General characters of major groups of plants and evolutionary relationships among these groups, Meristems, Simple and complex tissues, leaf, stem and wood anatomy

iii. Animal Biodiversity: Classification and General characters of major groups of animals and their evolutionary relationships. Different types of tissues. Skeletal, Nervous, Circulatory and Reproductive system of Man.

iv. Microbial Diversity: Classification of Bacteria: as per Bergey's Manual, Bacterial cell structure, Microbial growth. Cell division and genetic recombination

v. Viral Diversity: Classification of viruses based morphology, Nucleic acids and Host, ICTV.

UNIT 2: MOLECULES OF LIFE, METABOLISM

- i. **Biomolecules** : Composition, structure and function of biomolecules (carbohydrates, lipids, proteins, nucleic acids and vitamins).
- ii. **Principles of biophysical chemistry**: (pH, buffer, reaction kinetics, thermodynamics, colligative properties)
- iii. **Conformation of proteins**: (Ramachandran plot, secondary, tertiary and quaternary structure; domains; motif and folds).
- iv. **Conformation of nucleic acids**: (A-, B-, Z-,DNA, t-RNA)
- v. **Metabolism**: carbohydrates, lipids, amino acids and nucleotides
- vi. **Bioenergetics**, glycolysis, oxidative phosphorylation, coupled reaction, group transfer, biological energy transducers, Mitochondrial electron transport

UNIT 3: BIOCHEMICAL TECHNIQUES , ENZYMOLOGY:

- i. **Isolation and Separation methods**: Isolation and purification of RNA , DNA (genomic and plasmid) and proteins, different separation methods, Analysis of RNA, , Principle and applications of chromatography and electrophoresis. Centrifugation : Subcellular fractionation using differential and gradient centrifugation.
- ii. **Radiolabeling techniques**: Properties of different types of radioisotopes normally used in biology, their detection and safety guidelines. Preparation of end labeled DNA, fluorescent labeling.
- iii. **Spectroscopic techniques**: Principle and instrumentation of colorimetry Spectrophotometry, fluorimetry. Beer- Lambert's law and its limitation, extinction co-efficient and its application.
- iv. **Microscopic techniques**: Visualization of cells and subcellular components by light microscopy, resolving powers of different microscopes, microscopy of living cells, scanning and transmission microscopes, different fixation and staining techniques for EM, freeze-etch and freeze-fracture methods for EM, FACS, Confocal microscopy and applications
- v. **Enzyme Nomenclature**: Nomenclature and IUB classification of enzymes
- vi. **Enzyme Kinetics**: -Rate of a reaction, order and molecularity. Michaelis Menten equation, Turnover number.
- vii. **Enzyme Inhibition**:- Competitive, non competitive, uncompetitive and product inhibition. Irreversible inhibition, suicide inhibition
- viii **Mechnisms of Enzyme Catalysis**:- Active site structure. Methods of determining active site structure - isolation of ES complex, affinity labeling, chemical modification studies. Active site structure investigation

UNIT 4: PHYSIOLOGY

- i. Photosynthesis:** Light harvesting complexes; mechanisms of electron transport; photoprotective mechanisms; CO₂ fixation-C₃, C₄ and CAM pathways.
- ii. Respiration and photorespiration:** Citric acid cycle; plant mitochondrial electron transport and ATP synthesis; alternate oxidase; photorespiratory pathway.
- iii. Nitrogen metabolism:** Nitrate and ammonium assimilation; amino acid biosynthesis.
- iv. Plant hormones:** Types, physiological effects and mechanisms of action.
- v. Solute transport and photoassimilate translocation:** Uptake, transport and translocation of water from soil, through cells, across membranes, through xylem, transpiration; mechanisms of loading and unloading of photoassimilates.
- vi. Blood circulation:**
- vii. Respiratory system and respiration:** Types of respiration, transport of gases, exchange of gases, waste elimination..
- viii. Sensory physiology:** Neurons, action potential, neural control of muscle tone and posture. Sense organs: Vision, hearing and tactile response.
- ix. Excretion:** Formation of urine. Mechanism of urine concentration. Hormonal control of urine formation
- x. Thermoregulation:** Effect of Temperature on biological system. Temperature relations of Poikilotherms and homeotherms, acclimation and acclimatization to cold and heat.
- xi. Digestive system:** Digestion, absorption, energy balance, BMR.
- xii. Endocrinology:** Endocrine glands, basic mechanism of hormone action,.

UNIT 5: MOLECULAR CELL BIOLOGY, IMMUNOLOGY

- i. Membrane structure and function:** Structure of model membrane, lipid bilayer and membrane protein diffusion, osmosis, ion channels, active transport, ion pumps, mechanism of sorting and regulation of intracellular transport, electrical properties of membranes.
- ii. Structural organization and function of intracellular organelles:** Cell wall, nucleus, mitochondria, Golgi bodies, lysosomes, endoplasmic reticulum, peroxisomes, plastids, vacuoles, chloroplast, structure & function of cytoskeleton and its role in motility, Types of chromosomes
- iii. Organization of genes and chromosomes:** Interrupted genes, gene families, structure of chromatin and chromosomes, unique and repetitive DNA, heterochromatin, euchromatin, transposons.
- iv. Cell division and cell cycle:** Mitosis and meiosis, their regulation, steps in cell cycle, and control of cell cycle. Apoptosis, Cancer cells and stem cells.
- v. Cellular communication:** General principles of cell communication, cell adhesion and roles of different adhesion molecules, gap junctions, extracellular matrix, integrins, neurotransmission
- vi. Cells and molecules involved in innate and adaptive immunity,**
- vii. Antigens:** chemical nature and properties, antigenicity and immunogenicity.
- viii. Antibodies:** Structure, classes and function of antibody molecules, generation of antibody diversity, monoclonal antibodies,

ix. **Antigen-antibody interactions:** MHC molecules, antigen processing and presentation, activation and differentiation of B and T cells, humoral and cell-mediated immune responses, inflammation, hypersensitivity

UNIT6: MOLECULAR GENETICS , MOLECULAR BASIS OF DEVELOPMENT AND DIFFERENTIATION

i. **Mendelian principles:** Dominance, segregation, independent assortment,

ii. **Alleles:** multiple alleles, Lethal alleles, pseudoallele,

iii. **Extensions of Mendelian principles:** Codominance, incomplete dominance, gene interactions, linkage and crossing over, sex linkage, sex limited and sex influenced characters, Linkage and construction of genetic maps, Evolution of gene concept (Benzer's work)

iv. **Extra chromosomal inheritance**

v. **Mutation:** Types, causes and detection, mutant types – lethal, conditional, biochemical, loss of function, gain of function, insertional mutagenesis.

vi. **Structural and numerical alterations of chromosomes:** Deletion, duplication, inversion, translocation,

vii. **Molecular basis development and differentiation:** *Drosophila*: Primary axis formation during oogenesis. Generating dorsal – ventral pattern in embryo. Segmentation and the anterior – posterior body plan, segmentation genes, homeotic selector genes.

viii. **Morphogenesis and organogenesis in plants:** Embryogenesis, Organization of shoot and root apical meristem; transition to flowering, floral meristems and floral development in *Arabidopsis* and *Antirrhinum*.

UNIT 7: MOLECULAR PATHOLOGY AND SIGNAL TRANSDUCTION

i. **Host parasite interaction:** Recognition and entry processes of different pathogens like bacteria, viruses into animal and plant host cells, pathogen-induced diseases in animals and plants, Mechanism of disease resistance in plants.

ii. **Human diseases:** Nutritional deficiency diseases – vitamin, mineral and protein-calorie. Symptoms, diagnosis and treatment, Diseases of the liver-causes of liver diseases, hepatitis, cirrhosis jaundice, diagnosis and treatment, Heart-CVD, CHD, atherosclerosis, Diabetes – types, GTT, Role of insulin, origin and progression. Complication. Control / treatment, Endocrine disorders – disorders of under and over production of hormones

iii. **Cell signaling:** Types.

iv. **Hormones and their receptors:** Cell surface receptor, signaling through G-protein coupled receptors, secondary messengers.

vi. **Regulation of signaling pathways:** MAPK pathway, stress pathway, cytokine pathway.

vii. **Signaling in Bacteria:** Chemotaxis and quorum sensing.

viii. **Signaling in Plants:** Signaling through stress and light. .

UNIT 8: GENE EXPRESSION

i. DNA replication

ii. RNA synthesis and processing

iii. Genetic code

iv. Protein synthesis and processing

v. **Post-translational modification of proteins** : Signal cleavage, disulphide bond formation, Glycosylation, folding of nascent protein, role of chaperons

vi. Regulation of gene expression:

Regulation in prokaryotes: Lac operon: structure and regulation, tryptophan operon: attenuation control.

Regulation at the level of DNA structure: Super coiling, DNA methylation, role of nucleosome structure of eukaryotic DNA in gene expression.

Regulation at the level of Transcription –Transcription factors, Regulation at the level of RNA processing, RNA export and RNA stability.

Regulation at the level of Translation: e.g. Regulation of Ferritin and Transferrin mRNA. Role of upstream AUG codons, translational introns, protein splicing, inteins.

vii. **DNA Binding Protein Motifs**: Zinc finger, Leucine Zipper, Helix-Turn-Helix and other motifs

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UNIT 9: GENETIC ENGINEERING

i. Molecular cloning :

Restriction endonucleases : Types, blunt end and staggered cut , Ligation

Gene transfer methods: Transformation, Transfection, Electroporation, Biolistic method.

Vectors - plasmids, phage, cosmids and phagemid, yeast cloning vectors, plant vectors, bacterial artificial chromosome, SV40, shuttle vectors, phagemids, construction of expression vectors

Recombinant DNA techniques , *Agrobacterium* mediated transformation colony hybridization, plaque hybridization.

ii. **PCR**: Concept, methodology, types and applications

iii. **Expression** : Heterologous expression , Expression of recombinant proteins using bacterial, animal and plant vectors; generation of genomic and cDNA libraries; *in vitro* mutagenesis and deletion techniques, gene knock out in bacterial and eukaryotic organisms; protein sequencing methods, DNA sequencing methods, micro array based techniques.

iv. **Blotting techniques** - Dot blot, southern, northern, western blot, DNA foot print assay, DNA finger print assay and gel retardation assay, nuclease protection assay.

v. **RNAi**: Antisense construct, Micro RNA and their applications.

vi. **Cell Culture**: Plant cell culture: Micropropagation, callus culture, haploid production, somatic embryogenesis, somatic hybridization and cybridization , somaclonal variation. Animal Cell Culture:

Culture techniques, media preparation of primary culture, cell lines, characterization of cultures, cell doubling time, applications

vii. **Applications** of Genetic Engineering.

viii. **Biosafety**: Laboratory methodologies, Handling of GMOs, Testing, Evaluation, Toxicity, Allergenic & Animal ethical issues, Disposal methodologies, Natural guidelines, role of IBSC, RCGM and GEAC.

UNIT 10: GENOMICS AND PROTEOMICS

i. **Genomics and its types**: Structural Genomics, Functional Genomics,

ii. **Genome sequencing** :Raw genome sequence data, EST, Polymorphisms , SNPs, Types of physical maps. Genomic databases.

iii. Genome of *E.coli*, *Arabidopsis thaliana*, *C.elegans*, *D. Melanogaster*, Zebra fish, Human.

iv. **Sequence alignment and database searches**: DNA sequence analysis, Homology sequence analysis using BLAST , FASTA, Pairwise alignment, ORF Plotting, Gene Finding, Translation.Multiple sequence alignment using CLUSTAL W.

v. **Phylogenetic Analysis** :Phylogenetics data analysis, Tree building methods, Rooted tree, un rooted tree, Distance method

vi. **Introduction to proteomics**:, Protein digestion techniques, Mass Spectrometers for protein and peptide analysis. Protein identification by peptide mass fingerprints, peptide sequence analysis by tandem mass spectrometry.

vii. **Protein sequence analysis using softwares** : Protein expression profiling, , protein complexes. Mapping protein modifications. Protein secondary structure analysis, Molecular visualization of protein 3D structure.

viii. **Basics of** Molecular modeling and Drug designing
