Punyashlok Ahilyadevi Holkar Solapur University, Solapur

NAAC Accredited-2022'B++'Grade(CGPA2.96)

Name of the Faculty: Science& Technology

Syllabus: PhD. Biotechnology

Entrance Examination – Paper II

UNIT 1: PLANT SCIENCES

1. Photosynthesis – Light harvesting complexes; mechanisms of electron transport; photoprotective mechanisms; CO2 fixation-C3, C4 and CAM pathways.

2. Nitrogen metabolism – Nitrate and ammonium assimilation; amino acid biosynthesis.

3. Plant hormones – Biosynthesis, storage, breakdown and transport; physiological effects and mechanisms of action.

4. Gametogenesis and fertilization: pollen development, embryo sac development and double fertilization in angiosperm B Early development: Embryogenesis, establishment of symmetry in plants; seed formation and germination.

5. Morphogenesis and organogenesis in plants: Organization of shoot and root apical meristem, floral meristems and floral development.

6. Conventional Plant Breeding and Plant Tissue Culture, Terms Used In Plant Tissue Culture, Basic Techniques In Plant Tissue Culture. Aseptic manipulation, Embryo culture, Production of Haploids.

7. Greenhouse Technology, Advantages of Greenhouse, Classification of Greenhouse, Types Of Greenhouse Based On Shape, Utility, Material And Constructions.

UNIT 2: ANIMAL SCIENCES

1. Digestion: digestive system, Digestive fluids: Composition of bile, Saliva, Pancreatic, gastric and intestinal juice, Mechanism of digestion, absorption and assimilation of carbohydrates, proteins and lipids.
2. Circulation: Mechanism of working of heart, Cardiac output, cardiac cycle, Origin & conduction of heart beat, Composition of blood, Mechanism of coagulation of blood.
3. Reproductive system: Male and female reproductive system with hormonal regulation. Gametes: Structure of egg and sperm, types of eggs, spermatogenesis and oogenesis,
   Fertilization: External vs internal fertilization, encounter of spermatozoa and ova, capacitation and contact, acrosome reaction and penetration, activation of ovum, migration of pronuclei and amphimixis. Cleavage (plane, pattern and types), morulation, blastulation, fate map construction, gastrulation.
4. Nervous & chemical coordination: Neural tissue and nerve cells (Structure and function), Synapse (Electric and chemical), Endocrine gland and their hormones (Pituitary and Thyroid)
5. Respiration: Respiratory system, mechanism, Exchange of gases, Transport of O2 and CO2, Oxygen dissociation curve, Chloride shift.
6. Excretory system: Structure of Kidney, Ultrafiltration (function of Bowman capsule, Malphigian body), Urine formation
7. Culture and maintenance of primary and established cell lines; Biology of cultured cells – culture environment, cell adhesion, cell proliferation and differentiation; Characterization of cultured cells, cell viability and cytotoxicity and expression of culture efficiency
   Types of Stem cells, Stem cell culture techniques and their applications;

UNIT 3: ECOLOGY & ENVIRONMENT

1. Population Ecology: Characteristics of a population; population growth curves; population regulation; life history strategies (r and K selection); concept of metapopulation – demes and dispersal, interdemic extinctions, age structured populations.
2. Species Interactions: Types of interactions, interspecific competition, herbivory, carnivory, pollination, symbiosis. Community Ecology: Nature of communities; community structure and attributes; levels of species diversity and its measurement; edges and ecotones.
3. Structure and function of ecosystem; Energy flow in an ecosystem: food chains, food webs and ecological succession. Ecological Succession: Types; mechanisms; changes involved in succession; concept of climax.
4. Levels of biological diversity : genetic, species and ecosystem diversity; Biogeographic zones of India; Biodiversity patterns and global biodiversity hot spots Endangered and endemic species of India, Threats to biodiversity: Habitat loss, poaching of wildlife, man-wildlife conflicts, biological invasions; Conservation of biodiversity: In-•-situ and Ex-situ conservation of biodiversity.
5. Environmental pollution: types, causes, effects and controls; Air, water, soil and noise pollution, Nuclear hazards and human health risks, Solid waste management: Control measures of urban and industrial waste
6. Environmental Policies & Practices, Climate change, global warming, ozone layer depletion, acid rain and impacts on human communities and agriculture Environment Laws: Environment Protection Act, Air (Prevention, & Control of Pollution) Act; Water (Prevention and control of Pollution) Act; Wildlife Protection Act; Forest Conservation Act. International agreements: Montreal and Kyoto protocols and Convention on Biological Diversity (CBD).
7. Biotechnology for clean environment: Bioremediation, Biomaterials as substitutes for non-degradable materials (bioplastics, biofuel, bioinsecticide, and biofertilizer), Heavy Metal Pollution and impact on environment, Metal microbe interactions: Molecular mechanisms for heavy metal tolerance (Biosorption, bioaccumulation ,bioassimilation, bioprecipitation, bioleaching ,and biotransformation).

UNIT 4: MICROBIOLOGY & FERMENTATION BIOTECHNOLOGY

1. Morphology- Microscopic structure and macroscopic structures,
   Diversity and Reproduction of algae, fungi, slime molds and protozoans.
   Symbiosis- algae, fungi, slime molds and protozoans; Pathogenesisand Industrial applications of algae, fungi, slimemolds and protozoans.
   Virus and bacteriophages, general properties of viruses, viral structures,

2. Nutrition and Culture media: components of media, natural and synthetic media,chemically defined media, complex media, selective, differential, indicator, enriched andenrichment media. Living media- Eggs, cell lines, animals. Batch culture,Continuous culture, Synchronous growth, Diauxic growth, Microbial growth in response to environment.

3. Principles of isolation – Principles of microbial culture, Aseptic techniques, Principles and methods of sterilization, isolation and enumeration of microorganisms, staining techniques. Serial dilution, Streak plate, Pour plate,Spreadplate. Cell Enumeration Techniques- Direct methods, DMC, Neubauer chamber, IndirectMethods- SPC/TVC, Membrane filter technique.

4. Stains and staining procedures: Difference between dye and stain.ClassificationofStains – acidic, basic and neutral. Theories, Procedures and mechanisms of – Simplestaining, Differential staining, Gram staining, Acid fast staining, Negative staining,special staining- Capsule, Cell wall, Metachromatic granules.

5. Microscopy: Construction, Working, Principles & Application of- Bright Field Microscopy, Dark Field Microscopy, Phase Contrast Microscopy, Fluorescent Microscopy, Confocal microscopy, Scanning and Transmission Electron Microscopy

6. Bioreactors: Design of typical Bioreactor: Parts and their functions, Bioreactor types (Air lift, Bubble column, Packed bed, fluidized bed, Photobioreactor),
   Fermentation medium: formulation and sterilization. Air sterilization. Types of fermentation processes: (Batch, fed batch, continuous, submerged,and solid state).

7. Upstream processing – Inoculum development Media preparation, and sterilization of media, Strain Improvement, Screening, Inoculum Development and Scale up.

8. Downstream processing of biologicals- Separation of cells, foam separation, flocculation, filtration, plate filters, rotary vacuum filter, centrifugation, basket centrifuge, bowl centrifuge, disintegration of microorganisms, mechanical and non-mechanical methods, membrane filtration, ultrafiltration and reverse osmosis, chromatographic techniques, absorption, spray drier, drum dryers, freeze dryers.

9. Microbial products- Microbial production of vitamins, enzymes, organic acids, amino acids, antibiotics, ethanol. 6. Microbes for sustainable agriculture- Biological nitrogen fixation, Biofertilizers, Biological control, Biopesticides.

UNIT 5: BIOCHEMISTRY

1. Carbohydrates: Carbohydrates: Structure, properties and function of monosaccharide (glucose, fructose, mannose, galactose, ribose), disaccharide (sucrose, lactose), polysaccharide (starch, glycogen, cellulose, peptidoglycan).
   Glycolysis, Gluconeogenesis, TCA, Pentose Phosphate Pathway, Glycogen metabolism

2. Amino acids: General structure and properties of amino acids, zwitter ion, titration curve of amino acid (glycine), classification of amino acids based on R-group with structure, essential and non-essential amino acids.
   Amino acid metabolism-Decarboxylation, trans amination, deamination, Urea cycle

3. Proteins: Peptide bond, primary structure, secondary structure, tertiary structure, quaternary structure, forces stabilizing protein structure, classification of proteins based on composition. Conformation of proteins (Ramachandran plot, secondary structure, domains, motif and folds).

4. Nucleic acid: Composition, structure and nomenclature of nucleotides, Structure of B-form of DNA, RNA and its types. Conformation of nucleic acids (helix (A, B, Z), t-RNA, micro-RNA). Stability of proteins and nucleic acids.
   Nucleotide metabolism-De-novo and Salvage pathway

5. Lipids: Structure and properties of fatty acids, storage lipid (triacylglycerol, wax), membrane lipid (phospholipids, sphingolipids, sterol).
   Biosynthesis and beta oxidation of fatty acids

6. Vitamins: Source, daily requirements, physiological role, deficiency/hypervitaminosis of water soluble and fat soluble vitamins.

7. Bioenergetics, oxidative phosphorylation, coupled reactions, group transfer, biological energy transducers.

8. Principles of enzymology, structure and nomencleature of enzymes, enzyme kinetics, enzyme regulation - Product inhibition, feedback control, enzyme induction, enzyme inhibition - competitive, non- competitive and uncompetitive

9. Methods in Biochemistry: Various assays for the estimation of protein, carbohydrates and nucleic acids, enzyme assays
   Spectroscopy- UV-Visible, IR, NMR, X ray, mass spectroscopy.
   Chromatography- paper, gel filtration, ion exchange, affinity, gas, HPLC
   Electrophoresis - Agarose, Polyacrylamide - native, denaturing, 2Dimensional Gel Electrophoresis.

UNIT 6: CELL AND MOLECULAR BIOLOGY

1. Membrane structure and function- Structure of fluid mosaic model of the cell membrane, lipid bilayer, and transport across the membrane.
2. Structural organization and function - Intracellular cellular organelles, cytoskeleton elements, cell adhesion molecules, extracellular matrix proteins, vesicular trafficking and mechanisms of protein sorting.
3. Cell cycle and apoptosis - Mitosis and meiosis, cell cycle and its regulation, cell cycle check points, characteristics of apoptotic cells, apoptotic pathways, and assays to study cell cycle and apoptosis. Cell signaling- Types of signal transduction pathways and their regulation.
4. Cancer- Cancer theories that depict the onset and progression of cancer, role of oncogenes and tumor suppressor genes, characteristics of cancer cells and the mechanism(s) behind metastasis.
5. DNA replication: General properties of DNA replication and DNA polymerases, modes of DNA replication (e.g. theta replication, rolling circle etc.),
6. Transcription: Structural features of a gene (e.g. promoters, enhancers etc.), operon concept, mediators of transcription (e.g. RNA polymerases, general transcription factors etc.), types of RNA (e.g. mRNA, rRNA, tRNA etc.)
   Translation: Genetic code, translation initiation, elongation and termination, regulation of translationpost-translational modifications of proteins.
7. Methods in molecular biology: Methods of nucleic acid extraction and purification (e.g. phenol-chloroform extraction, agarose gel electrophoresis),
8. Hybridization based methods of nucleic acid estimation (e.g. Southern blotting, northern blotting, fluorescent in situ hybridization etc.), autoradiography.
9. Polymerase chain reaction (PCR), Standard PCR, RT (Reverse transcription)-PCR, Real Time PCR). DNA sequencing (Maxam and Gilbert, Sanger's, Automated DNA Sequencing.).

UNIT 7: GENETICS

1. Nature of genetic material: Griffith's transforming principle, experiments that proved DNA as the genetic material (e.g. Avery, McLeod and McCarty, and Hershey and Chase), Structure of DNA, morphology and organization of chromosome.
2. Principles of inheritance: chromosomal theory of inheritance,Concept of gene, Allele, multiple alleles, pseudoallele, complementation tests, co-dominance, incomplete dominance, genetic linkage,
3. Mendel's experiment, Monohybrid and Dihybrid crosses, Genotypic and phenotypic ratio, Law of Dominance, Law of segregation and Law of independent Assortment, Back cross and test cross. Modifications of Mendelian ratios: Co-dominance, Incomplete dominance, Interaction of complementary genes, supplementary gene, inhibitory gene, epistasis.
4. Linkage, significance of linkage. Crossing over– theories, types and mechanism. Gene Mapping – physical map and genetic map (by three-point test crosses), Mapping by tetrad analysis – the analysis of unordered and ordered Tetrads
5. Extra chromosomal inheritance and alleles - Genetic system in mitochondria, chloroplast, and plasmid, Sex linked Inheritance - Structure of Sex Chromosomes. Complete and incomplete sex linked genes, Bacterial Recombination – transformation, conjugation and transduction.
6. Mutations and mutagens, types of DNA damage, DNA repair mechanisms, diseases associated with defective DNA repair. Alterations of chromosomes : Deletion, duplication, inversion, translocation
7. Transposable elements- replicative and nonreplicative transposition. Eukaryotic trasnsposable elements – DNA transposases, retroposes (LINES, SINES), Satellite DNA (mini & micro)
8. Population Genetics - Hardy-Weinberg law, gene frequency, factors affecting gene frequency. Significance of population genetics.

UNIT 8: IMMUNOLOGY

1. Antigen: Introduction, immunogenicity, antigenicity, types of antigens, Haptens, properties of immunogen, role of biological system in immunogenicity, route of Administration. Processing and presentation of exogenous and endogenous antigens. Major Histocompatibility Complex: Introduction, classes – structure and function. Cytokines: Introduction, properties, function, Cytokine receptors. Complement system: Introduction, functions, components, general account on complement activation – classical and alternative pathways.
2. Antibody:, basic structure and biological function of antibody classes. Monoclonal antibodies: Hybridoma Technology for monoclonal antibody production and applications of monoclonal antibodies.
3. Complement system: Introduction, functions, components, general account on complement activation – classical and alternative pathways.
4. Native or Innate immunity: Introduction, First line of Defense – Physical and Chemical barriers at the portal of entry. Second line of Defense – Cellular Processes in nonspecific defense mechanism Structure and functions of primary lymphoid organs, secondary lymphoid organ Cells of immune system. Third line of Defense: Humoral Immunity and cell mediated Immunity. Primary and secondary immune response
5. Humoral and cell mediated immunity, primary and memory immune responses, B and T cell receptors, structure and function of antibody molecules, monoclonal antibodies, antibody engineering. MHC molecules, antigen processing and presentation, activation and differentiation of B and T cells.
6. Inflammation, allergy, and hypersensitivity reaction. Immunological tolerance - self non-self descrimination. Immuno hematology: ABO and Rh blood group system, applications of blood group, Hemolytic diseases of new born, detection of Rh antibodies, ABO hemolytic diseases
7. Immunological techniques- ELISA, RIA, Immunofluorescence, Western blot, Flow Cytometry.

UNIT 9: RECOMBINANT DNA TECHNOLOGY & GENETIC ENGINEERING

1. Enzymes (source and functions): Exonucleases (Exonuclease I, III and λ), Endonucleases (S1nuclease, Mung bean nuclease, DNase1, Ribonuclease H), Restriction endonuclease (Type I, II, III), Ligases (E. coli DNA Ligase, T4 - DNA Ligase, T4 - RNA Ligase), DNA polymerases (Polymerase I, klenow fragments, Taq), RNA polymerases (E. coli RNA polymerases, SP-6 RNA polymerases, T7 - RNA polymerases), Reverse transcriptases (AMV Reverse transcriptase, M-Mul V Reverse transcriptase), Alkaline phosphatases, Terminal deoxy nucleotidyl transferase, Kinases (T4 – Poly Nucleotide kinase, T4 – Poly Nucleotide kinase phosphatase free)
2. Plasmids,Cosmids, Phagemids, BAC, Shuttle vectors, YAC, plants and animals as vectors.
3. Construction of rDNA Molecules - Isolation of Vector and donor DNA and its purification; Assembly of gene of interest and vector DNA; Construction and screening of Genomic library and cDNA library.
4. Screening of Recombinant Cell – Direct Screening, Indirect Screening, Colony hybridization, Immuno-Screening. Molecular Probes- Genomic DNA probes, cDNA probes, synthetic oligonucleiotide probes,and RNA probes, methods of labeling probes.
5. DNA based methods of genetic analysis (e.g. RFLP, AFLP, RAPD etc.)
6. Random and site-directed mutagenesis: Primer extension and PCR based methods of site directed mutagenesis, Random mutagenesis, Gene shuffling, production of chimeric proteins, Protein engineering.
7. Gene targeting in mice, Therapeutic products produced by genetic engineering-blood proteins, human hormones and vaccines. Heterologous protein production in plant systems - edible vaccines, plantibodies, Transgenic plants.
   Detection and Diagnosis of Genetic diseases (sickle-cell anaemia, Thalasemia, Haemophilia and Cystic fibrosis) and infectious diseases (Malaria and TB) Gene therapy, DNA marker technology in plants, DNA fingerprinting.

UNIT 10: GENOMICS, PROTEOMICS & BIOINFORMATICS

1. Organization of genomes: Genome, Genomics, Omics and importance, General features, The origin of genomes- Origin of macromolecules, RNA world and DNA world , Genome diversity. Introduction to Molecular taxonomy.

2. Introduction to proteomics, Analysis of Proteomes- Two -dimensional polyacrylamide gel electrophoresis, Sample preparation, Solubilization, Reduction, Resolution, Reproducibility of 2DE. Detecting proteins in Polyacrylamide gels, Image analysis of 2-DE gels. Mass spectrometry based methods for protein identification, 2-DE gel electrophoresis coupled with mass spectrometry

3. The Human genome project, HapMap Project, The 1000 genome project, and The ENCODE Project.

4. Structural genomics: Assembly of a contiguous DNA sequence- Genome sequencing assembly clone counting method, and whole –genome shotgun sequencing, computer tools for sequencing project. Significance of genomes – Bacteria, Yeast, Drosophila, Caenorhabditis, Homo sapiens, Arabidopsis.

5. Primary Protein sequence databases:- PIR, MIPS, Swiss – PROT, TrEMBL, NRL – 3D; Composite Protein sequence databases: - NRDB, OWL, MIPSx, SWISS-PROT + TrEMBL; Secondary Protein databases: - PROSITE, Pfam, Structure classification databases: - SCOP, CATH, PDBsum.

6. Nucleic acid sequence databases: EMBL, DDBJ, GenBank; Structural Databases: - PDB, NDB, MMDB; Genomic database – Ensembl; Bibliographic databases – PubMed, PubMed Central, NCBI Bookshelf.

5. Global and Local alignments; Pairwise alignments – method, algorithm, scoring matrices, tools (e.g. BLAST and FASTA) and applications; Multiple alignments – consensus sequence, methods, tools (e.g. Clustal) and applications. Phylogenetic analysis: Elements of phylogeny, methods of phylogenetic analysis, Phylogenetic tree of life, phylogenetic analysis tools - Phylip.