

Syllabus for PET – 2026 (Biotechnology)

1) Fundamental 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.

2) Biomolecular structure and function in living system:

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

3) 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.

4) Cellular processes:

DNA replication, repair and 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

5) 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.

6) 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. 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. 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.

7) 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.

8) **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 Sequence based 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,

9) **Plant 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, 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; α -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 β -carotene accumulation; Production of antibodies and pharmaceuticals in plants. Biofuels, Bacillus thuringiensis: molecular basis of insecticidal activity. Agriculturally important microorganisms and their application. Abiotic and Biotic

Stress Biology a) Abiotic stress: Acclimation and crop adaptation to water, salinity, photo oxidative, heavy metal, heat and cold, nutrient stress. Metabolite engineering for abiotic stress tolerance, Functional genomics of stress tolerance. Induced systemic tolerance. b) Biotic stress: Plant response to pathogens and herbivores, biochemical and molecular basis of host plant resistance, toxins of fungi and bacteria, systemic and induced resistance, pathogen derived resistance, signaling - gene for gene hypothesis, genetic engineering for biotic stress resistance, gene pyramiding. Induced systemic resistance, systemic acquired resistance.

10) 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 animal 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

11) 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. 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. Pollution monitoring: chemical, biological and molecular methods; Environmental impact assessment, Biodiversity and its conservation, GMOs and Biosafety. Global environmental problems: Ozone depletion, UV-B and green house gases

12) IPR, Biosafety & Bioethics:

Types of IP: Patents, Trademarks, Copyright & Related Rights, Industrial Design, Traditional Knowledge, Geographical Indications, Protection of New GMOs; International framework for

the protection of IP. IP as a factor in R&D; IPs of relevance to Biotechnology and few Case Studies; Introduction to History of GATT, WTO, WIPO and TRIPS. Invention in context of “prior art”; Patent databases; Searching International Databases; Country-wise patent searches (USPTO, EPO, India etc.); Analysis and report formation. Types of patents; Indian Patent Act 1970; Recent Amendments; Filing of a patent application; Precautions before patenting-disclosure/non-disclosure; WIPO Treaties; Budapest Treaty; PCT and Implications; Role of a Country Patent Office; Procedure for filing a PCT 9 application. Patent application- forms and guidelines, fee structure, time frames; Types of patent applications: provisional and complete specifications; PCT and convention patent applications; International patenting-requirement, procedures and costs, Patent infringement meaning, scope, litigation, case studies and examples. Biosafety: Introduction; Historical Background; Introduction to Biological Safety Cabinets; Primary Containment for Biohazards; Biosafety Levels; Biosafety Levels of Specific Microorganisms; Recommended Biosafety Levels for Infectious Agents and Infected Animals; Biosafety guidelines - Government of India; Definition of GMOs & LMOs; Roles of Institutional Biosafety Committee, RCGM, GEAC etc. for GMO applications in food and agriculture; Environmental release of GMOs; Risk Analysis; Risk Assessment; Risk management and communication; Overview of National Regulations and relevant International Agreements including Cartagena Protocol. Bioethics: Concepts; Philosophical considerations; Epistemology of Science; Ethical Terms; Principles & Theories; Relevance to Biotechnology; Ethics and the Law Issues: Genetic Engineering, Stem Cells, Cloning, Medical techniques, Trans-humanism, Bioweapons; Research concerns - Animal Rights, Ethics of Human Cloning, Reproduction and Stem Cell Research; Emerging issues: Biotechnology’s Impact on Society; DNA on the Witness Stand - Use of genetic evidence in civil and criminal court cases; Challenges to Public Policy – To Regulate or Not to Regulate; Improving public understanding of biotechnology products to correct misconceptions.

13) IMMUNOLOGY:

Innate immunity, cell, CD nomenclature; Experimental Systems used in the Immunology; Acquired immunity, T-cells, B-cells; Immunoglobulins, class, sub-class and structure; Super Antigens and T-Cell Activation; Antibody combining sites, conformational changes; Immunoglobulin superfamily, affinity, avidity; Complement System, Antigenicity & Immunogenicity; Antigen Processing & Presentation; Cell-cell interaction, adhesion molecules; Antigen Processing & Presentation; B-cell activation and differentiation – generation of humoral response; Antibody mediated Effector mechanisms; Cell mediated Effector mechanism; Immunization strategies; Cytokines, characteristics and function;

Monoclonal antibody production; Antibody screening Assays; Cytokine classes and their biological activities; Characterization of monoclonal antibodies.

14) MICROBIOLOGY:

Development of microbiology as a scientific discipline, Methods of studying microorganisms, Organization and structure of microbes- morphology of bacteria, yeast and molds, algae, protozoa, virus, prions. Microbial morphology: capsule, slime layer, pili, flagella, cell wall, matrix material, chemo-taxis bacterial growth and reproduction – pure culture and cultural characteristics. Control of microorganisms – physical and chemical agents; antibiotics and chemotherapeutic agents.

15) BIostatistics & Computers:

Definition of selected terms Scale of measurements Related to statistics; Methods of collecting data; Presentation of data statistical Tables; Need for reduction of data measures of averages and location; Measures of dispersion Range quartile deviation mean deviation & relative deviation; Concepts of statistical population and sample need for sampling studies; Simple procedures of random sampling; Methods of sampling; Probability Statistics in Genetics; Introduction to Computer Science; Introduction to Data-Base; Introduction to Windows; Windows Application (Word, Excel, PowerPoint and Multimedia); Introduction to INTERNET & use of Electronic Mail; Introduction to Medical Informatics & use of Statistical Package; Introduction to UNIX & C; Computer Aided Teaching & testing.