

## BIOTECHNOLOGY

### UNIT-I Cell Biology

Cell, cell theory and diversity, membrane structure, function and transport, membrane pumps, cell wall and ECM.

Structure and function of cellular organelles, mechanism of vesicular transport, chromosomes & Chromatin organization - histone and DNA interactome

Cell signaling, Molecular mechanisms of membrane transport, nuclear transport, transport across mitochondria and chloroplasts; intracellular vesicular trafficking from endoplasmic reticulum through Golgi apparatus to lysosomes/cell exterior

Cell communication, cellular junctions & adhesions.

Cancer biology, Cell cycle and its regulation; cell division: mitosis, meiosis and cytokinesis; cell differentiation: stem cells, their differentiation into different cell types and organization into specialized tissues; cell-ECM and cell-cell interactions; cell receptors and transmembrane signalling; cell motility and migration; cell death: different modes of cell death and their regulation.

Developmental Biology: Development of *Drosophila* and *C.elegans*.

### UNIT-II General & Applied Microbiology, Molecular Virology

Morphology, structure, growth and nutrition of bacteria, bacterial growth curve, bacterial culture methods; bacterial genetics: mutation and recombination in bacteria, plasmids, transformation, transduction and conjugation; antimicrobial resistance, Sterilization, disinfection and antisepsis: physical and chemical methods for control of microorganisms, antibiotics, antiviral and antifungal drugs, biological control of microorganisms, microbial growth & nutrition.

Microbial taxonomy and evolution of diversity, classification of microorganisms, eukarya, Archaea, viruses.

Methods for determining evolutionary relationships, metabolic diversity.

Anaerobic respiration, nitrogen fixation, syntrophy, important microbial diseases.

Industrial microorganisms and product formation, use of microbes in genetic engineering.

Virus and bacteriophages, general properties of viruses, viral structure, taxonomy of virus, mechanisms of viral entry and spread of infection/ viral pathogenesis, viral replication, cultivation and identification of viruses; sub-viral particles – viroids and prions

Types of viruses and viral diseases, cellular interactions, virus uncoating mechanisms, host resistance to viral infections, viral vaccines, modern approaches of virus control.

### **UNIT-III Biochemistry & Metabolism**

Occurrence, classification, structure of disaccharides and polysaccharides.

Metabolic pathways – regulation and significance.

Structure & classification of proteins and amino acids; functions of proteins.

Amino acid metabolism and degradation, titration curves, urea cycle.

Photosynthesis and ATP synthesis, ETC & shuttle system.

Lipids classification, synthesis & metabolism; biosynthesis of fats and cholesterol; ketogenesis.

Chemistry & structure of nucleic acids, purine and pyrimidine metabolism & regulation.

Genetic disorders and hyperuricemia.

### **UNIT-IV Molecular Biology and Genetic Engineering**

Structure, function and replication of DNA and RNA, Alternate forms of DNA, Genetic Code, RNA as a biocatalyst, Ribozymes.

Mechanism of transcription and translation in prokaryotes and eukaryotes.

Regulation of transcription and translation.

Cloning, cloning vectors and molecular tools, *E. coli* as a model organism.

Isolation, purification, quantitation and electrophoresis of nucleic acids.

Blotting methods, vector construction, transformation, library formation, codon optimization.

Types of PCR – multiplex, nested; reverse-transcription PCR, real time PCR, touchdown PCR, hot start PCR, colony PCR, asymmetric PCR, PCR based site specific mutagenesis; PCR in molecular diagnostics; viral and bacterial detection; sequencing methods; enzymatic DNA sequencing; chemical sequencing of DNA; automated DNA sequencing; RNA sequencing; chemical synthesis of oligonucleotides; mutation detection: SSCP, DGGE, RFLP.

Gene silencing techniques; siRNA technology; Micro RNA, gene knockouts and gene therapy

Transgenics - gene replacement, gene targeting, creation of transgenic and knock-out mice, disease model, genome editing by CRISPR-CAS

### **UNIT-V Enzymology and Bioprocess Engineering**

Enzymes – nomenclature, classification, significance and structure.

Mechanism of enzyme action, bioenergetics.

Steady state vs equilibrium assumption, factors affecting enzyme activity, enzyme inhibitions.

Regulatory enzymes, enzyme purification, chromatography, industrial applications of enzymes.  
Industrially important microbes; microbial growth and death kinetics, strain improvement, yield coefficients; unstructured models of microbial growth; structured models of microbial growth.  
Fermentation, bioreactors, bioprocess economics, scale up, conventional fermentation v/s biotransformation; large scale animal and plant cell cultivation  
Bioprocess based industrial production of chemicals.  
Downstream processing and effluent treatment.  
Sterilization & pasteurization of food products, food preservation and hygiene, Hurdle concept, HACCP System.

#### **UNIT-VI Genetics, Genomics and proteomics**

Prokaryotic and eukaryotic genome organization; extra-chromosomal DNA: bacterial plasmids, mitochondria and chloroplast.

Mendelian genetics, Crossing over and Linkage, bacterial genetic system.

Molecular markers, genome mapping, genetic and physical maps; linkage analysis, cytogenetic techniques, FISH technique in gene mapping, somatic cell hybridization, radiation hybrid maps, in situ hybridization, comparative gene mapping

Mutation, transposons, human pedigrees, single gene inheritance.

Multiple alleles, Non disjunction; Dosage compensation.

Sex determination, molecular genetics.

Human Genome Project, genome sequencing projects for microbes, plants and animals

Proteomics, proteomics technologies, 2D-PAGE, isoelectric focusing, mass spectrometry, MALDI-TOF, yeast 2-hybrid system, proteome databases

Functional genomics and proteomics, transcriptome, Contig assembly, chromosome walking and characterization of chromosomes, mining functional genes in genome,

Gene function- forward and reverse genetics, gene ethics; protein-protein and protein-DNA interactions; protein chips and functional proteomics, metabolomics, lipidomics, metagenomics and systems biology

#### **UNIT-V Immunology**

Immune system: Innate and acquired immunity, clonal nature of immune response

Organs of immune system, primary and secondary lymphoid organs

Hematopoiesis, Cells of the immune system: B- lymphocytes, T- lymphocytes, Macrophages, Dendritic cells, Natural killer and Lymphokine activated killer cells, Eosinophils, Neutrophils, Mast cells.

Antigens, super antigens, immunogens, haptens, pathogen recognition receptors (PRR) and pathogen associated molecular pattern (PAMP)

Antibody structure and function, antibody mediated effector functions, antibody classes and biological activity, Antigenic determinants on immunoglobulins, Immunoglobulin superfamily.

BCR & TCR, generation of antibody diversity.

Regulation of immune response, Antigen processing and presentation, generation of humoral and cell mediated immune responses, Activation of B- and T- lymphocytes.

Complement System, Cytokines, Major Histocompatibility Complex: MHC genes, MHC and immune responsiveness and disease susceptibility.

Cell-mediated cytotoxicity (T cell, NK cell, Antibody dependent cell mediated cytotoxicity, macrophage mediated cytotoxicity).

Autoimmunity, Hypersensitivity, Transplantation immunology, Immunological tolerance, central tolerance, peripheral tolerance, component of peripheral tolerance.

Immunodiagnostic procedures: ELISA and its variants, ELISPOT, Radio immunoassay, Immunofluorescence, Flow cytometry and Fluorescence, Immunoelectron microscopy, Agglutination, haemagglutination assays, immunodiffusion, immunoelectrophoretic procedures, isoelectric focusing, Affinity chromatographic methods and Immunoblotting, surface plasmon resonance, biosensor assays for assessing ligand –receptor interaction; CMI techniques: lymphoproliferation assay, mixed lymphocyte reaction, cell cytotoxicity assays, apoptosis, microarrays, transgenic mice, gene knock outs.

Immunobiotechnology: Hybridoma Technology, Vaccines, vaccine design and development, Active and passive immunization.

**UNIT-VI Plant and Animal Biotechnology**

**Plant tissue culture** – history, types & requirements, totipotency; organogenesis; Somatic embryogenesis; establishment of cultures, callus culture, cell suspension culture, micropropagation; somaclonal variation; androgenesis, germplasm conservation and cryopreservation; synthetic seed production; protoplast culture and somatic hybridization - somatic hybridization, cybrids and somatic cell genetics; plant cell cultures for secondary



metabolite production, transgenics, molecular marker aided breeding, gene transfer in plants, Agrobacterium-mediated gene delivery, cointegrate and binary vectors, direct gene transfer - PEG-mediated, electroporation, particle bombardment and alternative methods; screenable and selectable markers; characterization of transgenics; chloroplast transformation; marker-free methodologies; advanced methodologies - cisgenesis, intragenesis and genome editing; molecular pharming - concept of plants as biofactories, production of industrial enzymes and pharmaceutically important compounds

**Animal cell culture:** cell culture medias, culture of mammalian cells, tissues and organs; primary culture, secondary culture, continuous cell lines, Monolayer and suspension cultures  
Cell viability & cytotoxicity, animal organ culture, Scale-up in monolayer and suspension culture; cryopreservation, somatic cell cloning and hybridization.

Animal reproductive biotechnology: Structure and cryopreservation of sperm & ova, artificial insemination, animal cloning, transgenic animal production, cryopreservation of embryos; embryo transfer technology

Methods for characterization of animal genomes, animal models for human genetic disorders.

Ethical issues in animal cloning & stem cell research.

#### **UNIT-VII Bioinformatics and Biostatistics**

**Bioinformatics,** Introduction to Unix and Linux systems and basic commands;

Biological database, protein and nucleic acid databases; structural databases, primary, secondary, functional, composite, structural classification database, Sequence formats & storage, Access databases, Extract and create sub databases, limitations of existing databases.

Local alignment, Global alignment, Scoring matrices - PAM, BLOSUM, Gaps and penalties, Dot plots. Dynamic programming approach: Needleman and Wunsch Algorithm, Smith and Waterman Algorithm, Hidden Markov Model, Heuristic approach: BLAST, FASTA. Building Profiles, Profile based functional identification

sequence alignment; pairwise alignment techniques; motif discovery and gene prediction; local structural variants of DNA, Multiple sequence alignment, CLUSTALW and CLUSTALX, Sequence submission tools, Protein modeling, Protein structure prediction, homology modeling, structure prediction, protein function prediction.

Retrieval Systems, Human Genome Project, Genome Sequencing, Genome Maps & their uses.

Sequence assembly, Genome analysis, Phylogenetic analysis.

Comparative genomics: cluster of orthologous groups(COGs), Homologene at NCBI

**Biostatistics:** Population, sample, measures of central tendency and measures of dispersion, probability and its types, permutation, combination, probability computations, theoretical distributions: Binomial, Poisson and Normal, hypothesis testing; two types of errors, Tests of significance; t-test, chi-square test, one way and two way analysis of variance, simple correlation and regression.

#### **UNIT-VIII IPR and Bioethics**

**IPR:** Intellectual property; 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, IPs of relevance to biotechnology, GATT, WTO, WIPO and TRIPS; plant variety protection and farmers rights act, prior art, patent databases - country-wise patent searches (USPTO, EPO, India)

Types of patents; Indian Patent Act 1970; recent amendments; WIPO Treaties; Budapest Treaty; Patent Cooperation Treaty (PCT), types of patent applications, introduction to existing schemes; publication of patents-gazette of India, status in Europe and US; patent infringement, commercialization of patented innovations; licensing – outright sale, licensing, royalty, backward and forward IP

**Biosafety and Biosecurity** -Biological safety cabinets; primary containment for biohazards; biosafety levels; GRAS organisms, biosafety levels of specific microorganisms; recommended biosafety levels for infectious agents and infected animals; definition of GMOs & LMOs; familiarity and substantial equivalence; risk – environmental risk assessment and food and feed safety assessment; problem formulation – protection goals,

International regulations – Cartagena protocol, OECD consensus documents and Codex Alimentarius; Indian regulations – EPA act and rules, guidance documents, regulatory framework – RCGM, GEAC, IBSC and other regulatory bodies;

Draft bill of Biotechnology Regulatory authority of India - containments – biosafety levels and category of rDNA experiments; field trials – biosafety research trials – standard operating procedures - guidelines of state governments;

GM labeling – Food Safety and Standards Authority of India (FSSAI).

Ethical conflicts in biological sciences - bioethics in health care, Bioethics in research, Protection of environment and biodiversity – biopiracy

**UNIT-IX Environmental Biotechnology and Nanotechnology**

Pollution, its types and control, eutrophication, ozone depletion, energy resources.

Biodiversity and its conservation, role of microorganisms in geochemical cycles; microbial energy metabolism, microbial ecology

Waste water treatment & its microbiology, pollution management, soil erosion.

Bioremediation & biodegradation, Biopesticides and Integrated Pest management.

Phytoremediation, phytoaccumulation, phytovolatilization, rhizofiltration phytostabilization.

Bioinsecticides, Biofungicides, Biofertilizers, Plant growth promoting rhizobacteria (PGPR) – uses, practical aspects and problems in application.

Biopollution, Biopolymers, Bioplastics, Biofuels, Biogas; Bioethanol, Biodiesel, Biohydrogen,

Bioleaching of metals, Biosurfactants; bioemulsifiers and Biomining.

**Nanotechnology** – history, origin, concepts, classification.

Nanomaterials- formats, properties, synthesis, characterization and applications.

Technique and principle of FT-IR and UV-VIS, basics of X-Ray diffraction, TGA, BET etc.

Nanoparticles for drug delivery, concepts and advantages, naotoxicology.