## 9. BOTANY

### CELL AND MOLECULAR BIOLOGY OF PLANTS

**Cell Wall :** Structure and functions, biogenesis, growth.

**Plasma membrane :** Structure, models and functions : Sites for ATPases, Ion carriers, Channels and pumps, Receptors.

**Plasmodesmata :** Structure, Role in movement of molecules and macromolecules, Comparison with gap junctions.

**Chloroplast :** Structure, genome organization, gene expression, RNA editing, nucleo-chloroplastic interactions.

**Mithochondria :** Structure, genome organization, Biogenesis.

**Plant Vacuoles :** Tonoplast membrane, ATPases, transporters, as storage organelle.

**Nucleus :** Structure, nuclear pores, nucleosome organization, DNA structure : A, B and Z forms, replication, damage and repair, transcription, Plant promoters and transcription factors, splicing mRNA transport, nucleolus, rRNA biosynthesis.

**Ribosomes :** Structure, site of protein synthesis, mechanism of translation, initiation, elongation and termination; structure and role of tRNA.

**Protein sorting :** Targeting of proteins to organelles.

**Cell shape and motility :** The cytoskeleton; organization and role of microtubules and microfilaments; motor movements; implications in flagellar and other movements.

**Cell cycle and apoptosis :** Control mechanisms; role of cyclins and cyclin dependent kinases; retinoblastoma and E2F proteins; cytokinesis and cell plate formation; mechanisms of programmed cell death.

**Other cellular organelles :** Structure and functions of microbodies, Golgi apparatus, lysosomes, endo plasmic reticulum.

**Techniques in cell biology :** Immuno techniques; in situ hybridization, FISH, GISH; confocal microscopy.

### CYTOLOGY, GENETICS AND CYTOGENETICS

**Chromatin organization :** Chromosome structure and Packaging of DNA, molecular organization of centromere and telomere; nucleolus and ribosomal RNA genes ; euchromatin and heterochromatin ; karyotype analysis ; banding patterns ; specialized types of chromosomes ; polytene, lampbrush, B-chromosomes and sex chromosomes ; molecular basis of chromosome pairing.

**Structural and numerical alterations in chromosomes :** Duplication, deficiency, inversion and translocation ; autopolyploids ; allopolyploids ; evolution of major crop plants.

**Genetics of prokaryotes and eukaryotic organelles :** genetic recombination in phage ; genetic transformation, conjugation and transduction in bacteria ; genetics of mitochondria and chloroplasts cytoplasmic male sterility.

**Gene structure and expression :** Genetic fine structure ; cis – trans test ; Benzer's experiment; introns and their significance ; RNA splicing ; regulation of gene expression in prokaryotes and eukaryotes.

**Genetic recombination and genetic mapping :** Recombination ; independent assortment and crossing over ; molecular mechanism of recombination ; role of RecA and RecBCD enzymes ; site-specific recombination ; chromosome mapping, linkage groups, genetic markers, construction molecular maps.

**Mutations :** Spontaneous and induced mutations ; physical and chemical mutagens ;

molecular basis of gene mutations ; transposable elements in prokaryotes and eukaryotes ; mutations induced transposons ; site-directed mutagenesis ; DNA damage and repair mechanisms.

**Plant Breeding :** Principles and methods of plant breeding ; Marker assisted breeding.

**Biostatistics :** Mean, Variance, Standard deviation, Standard error, Student't' test, chi-square and ANOVA.

**Molecular cytogenetic :** Nuclear DNA content; C-value paradox; cot curve and its significance; restriction mapping – concept and techniques ; multigene families and their evolution.

**BIOLOGY AND DIVERSITY OF LOWEER PLANTS : CRYPTOGAMS**

**Microbiological techniques :** Pure culture, enrichment and anaerobic culture.

**Importance of microorganisms :** Microbes in medicine, agriculture and environment.

**Microbial growth :** Nutritional requirements of microorganisms and methods to measure growth.

**Microbial Ecology :** Genetrification ; phosphorous solubilization ; nitrogen fixation

**Phycology :** Thallus organization ; cell ultra structure ; reproduction (vegetative, sexual, asexual) ; criteria for classification of algae : pigments, reserve food, flagella ; classification, salient features of Chlorophyta, Charophyta, Xanthophyta, Bacillariophyta, Phaeophyta and Rhodophyta ; algal blooms, algal biofertilizers ; algae as food, feed and uses in industry.

**Mycology :** General characters of fungi ; substrate relationship in fungi ; cell ultrastructure ; unicellular and multicellular organization ; cell wall composition ; nutrition (saprobic, biotropic, symbiotic) ; reproduction (vegetative, asexual, sexual) ; heterothallism ; heterokaryosis parasexuality ; Molecular aspects in classification.

General account of Mastigomycotina, Zygomycotina, Ascomycotina, Basidiomycotina, Deuteromycotina ; fungi in industry, medicine and as food ; fungal diseases in plants and humans ; Mycorrhizae ; fungi as biocontrol agents.

**Bryophyta :** Morphology, structure, reproduction and life history ; distribution ; classification, general account of Marchantiales, Junger maniales, Anthoceratales, Sphagnales, Funariales and Polytrcales ; economic and ecological importance.

**Pteridophyta :** Morphology, anatomy and reproduction ; classification ; evolution of stele ; heterospory and origin of seed habit; general account of fossil pteriodophyta ; introduction to Psilo psida, Lycopsida, Sphenopsida and Pteropsida.

**TAXONOMY AND DIVERSITY OF SEED PLANTS**

**Introduction and classification of Gymnosperms**

**Structure and reproduction in** Cycadales, Ginkgoales, Coniferales, Ephedrales, Welwitschiales and Gnetales.

**The species concept:** Taxonomic hierarchy, species, genus, family and other categories ; principles used in assessing relationship, delimitation of taxa and attribution of rank.

Salient features of the International Code of Botanical nomenclature.

**Taxonomic tools :** Herbarium ; floras ; histological, cytological, phytochemical, serological, biochemical and molecular techniques ; computers and GIS.

**Systems of angiosperm classification :** Phenetic versus phylogenetic systems ; cladistics in taxonomy ; relative merits and demerits of major systems of classification.

**Concepts of phytogeography :** Endemism, hotspots; plant explorations; invasions and introductions.

**PLANT PHYSIOLOGY AND METABOLISM**

**Energy flow :** Principles of thermodynamics, free energy and chemical potential, redox reactions, structure and functions of ATP.

**Fundamentals of enzymology :** General aspects, allosteric mechanism, regulatory and active sites, isoenzymes, kinetics of enzymatic catalysis, Michaelis – Menton equation and its significance.

**Membrane transport and translocation of water and solutes :** Plant water relations, mechanism of water transport through xylem, passive and active solute transport, membrane transport proteins.

**Signal transduction:** Receptors and G-proteins, phospholipid signaling, role of cyclic nucleotides, calcium calmodulin cascade, diversity in protein kinases and phosphatases.

**Photochemistry and photosynthesis :** Photosynthetic pigments and light harvesting complexes, photo oxidation of water, mechanisms of electron and proton transport, carbon assimilation – the Calvin cycle, photorespiration and its significance, the $C_4$ cycle, the CAM pathway, biosynthesis of starch and sucrose.

**Respiration and lipid metabolism :** Glycolysis, the TCA cycle, electron transport and ATP synthesis, pentose phosphate pathway, glyoxylate cycle, alternative oxidase system, structure and function of lipids, fatty acid biosynthesis, synthesis of membrane lipids, structural lipids and storage lipids and their catabolism.

**Nitrogen fixation and metabolism :** Biological nitrogen fixation, nodule formation and nod factors, mechanism of nitrate uptake and reduction, ammonium assimilation.

**Photobiology :** Photochromes and cryptochromes, photophysiology of light –induce responses, cellular localization.

**Plant growth regulators and elicitors :** Physiological effects and mechanism of action of auxins, gibberellins, cytokinins, ethylene, abscisic acid, brassinosteroids, polymines, jasmonic acid and salicyclic acid.

**The flowering process :** Photoperiodism, endogenous clock and its regulation, floral induction and development – genetic and molecular analysis, role of vernalization.

**Stress physiology :** Plant responses to biotic and abiotic stress; mechanisms of biotic and abiotic stress tolerance, HR and SAR, water deficit and drought resistance, salinity stress, metal toxicity, freezing and heat stress, oxidative stress.

**Coping with biotic stress :** Chemical control, Biological control, IPM

**PLANT DEVELOPMENT AND REPRODUCTION**

**Shoot development :** Organization of the shoot apical meristem (SAM); control of cell division and cell to cell communication; control of tissue differentiation especially xylem and phloem ; secretory ducts and laticifers.

**Phyllotaxy and leaf differentiation**

**Root development :** Organization of root apical meristem (RAM); cell fates and lineages; vascular tissue differentiation; homeotic muntants in Arabidopsis and Antirrhinum, sex determination.

**Male gametophyte**: Structure of anthers; microsporogenesis, role of tapetum; pollen development and gene expression; male sterility; sperm dimorphism and hybrid seed production; pollen germination, pollen tube growth and guidance ; pollen storage ; pollen allergy, pollen embryos.

**Female gametophyte:** Ovule development; megasporogenesis; organization of the embryo sac, structure of the embryo sac cells.

**Pollination, pollen – pistil interaction and fertilization :** Floral characteristics, pollination mechanisms and vectors; self-incompatibility; double fertilization.

**Seed development and fruit growth:** Endosperm development during early, maturation and desiccation stages; embryogenesis, cell lineages during late embryo development; storage proteins of endosperm and embryo; polyembryony; apomixes; embryo culture; fruit maturation.

**Dormancy:** Seed dormancy; overcoming seed dormancy; bud dormancy.

**Senescence and programmed cell death (PCD):** Types of cell death, PCD in the life cycle of plants, metabolic changes associated with senescence and its regulation; influence of hormones and environmental factors on senescence.

**PLANT ECOLOGY**

**Climate, soil and vegetation patterns of the world:** Life zones; major biomes and major vegetation and sol types of the world.

**Vegetation organization:** Concepts of community and continuum ; analysis of communities(analytical and synthetic characters)

**Ecological succession**: Hydrosere and xerosere.

**Ecosystem organization**: Structure and functions; primary production (methods of measurement, global pattern, controlling factors); energy dynamics (trophic organization, energy flow Pathways, ecological efficiencies); litter fall and decomposition (mechanism, substrate quality land climatic factors); global biogeochemical cycles of C,N,P and S; mineral cycles (pathways, processes, budgets) in terrestrial and aquatic ecosystems.

**Biological diversity**: Concept and levels; role of biodiversity in ecosystem functions and stability ; speciation and extinction; IUCN categories of threat; distribution and global patterns, terrestrial biodiversity hot spots; inventory.

**Air, water and soil pollution:** Kinds, sources, quality parameters; effects on plants ecosystems.

**Climate change:** Green house gases ($CO_2$, $CH_4$, $N_2O$, CFCs: sources, trends and role); ozone layer and ozone hole ; consequences of climate change ($CO_2$ fertilization, global warming, sea level rise, UV radiation).

**Ecosystem stability :** Concept (resistance and resilience); ecological perturbations (natural and anthropogenic) and their impact on plants and ecosystems ; ecology of plant invasion ; environmental impact assessment ; ecosystem restoration.

**Ecological management :** Concepts; sustainable development; sustainability indicators.

**PLANT RESOURCE UTILIZATION AND CONSERVATION**

**Plant Biodiversity and sustainable development**

**Origin, evolution, botany, cultivation and uses of** (i) Food forage and fodder crops (ii) fibre crops (iii) medicinal and aromatic plants and (iv) vegetable oil-yielding crops. Ethnobotany

**Important fire-wood and timber – yielding plants and non-wood forest products (NWFPs)** such as bamboos, rattans, raw materials for paper-making, gums, tannins, dyes, resins and fruits.

**Green revolution :** Benefits and adverse consequences.

**Plants used as avenue trees** for shade, pollution control and aesthetics.

Principles of conservation; extinctions; environmental status of plants based on International Union for Conservation of Nature.

**Strategies for conservation – in situ conservation :** International efforts and Indian initiatives ; protected areas in India – sanctuaries, national parks, biosphere reserves, wetlands,

mangroves and coral reefs for conservation of wild biodiversity.

**Strategies for conservation – ex situ conservation :** Principles and practices; botanical gardens, field gene banks, seed banks, in vitro repositories, cryobanks; general account of the activities of Botanical Survey of India (BSI), National Bureau of Plant Genetic Resources (NBPGR), Indian Council of Agricultural Research (ICAR), Council of Scientific and Industrial Research (CSIR) and the Department of Biotechnology (DBT) for conservation, non-formal conservation efforts.

**BIOTECHNOLOGY AND GENETIC ENGINEERING OF PLANTS AND MICROBES**

**Plant Biotechnology –** Principles, scope and applications.

**Plant cell and tissue culture :** General introduction, scope, cellular differentiation, and totipotency.

**Organogenesis and adventives embryogenesis :** Morphogenesis; somatic embryogenesis.

**Somatic hybridization :** Protoplast isolation, fusion and culture.

**Applications of plant tissue culture :** Clonal propagation, artificial seed, production of hybrids and soma clones, production of secondary metabolites / natural products, cryopreservation and germplasm storage.

**Recombinant DNA technology :** Gene cloning principles and techniques, genomic / c DNA libraries, vectors, DNA synthesis and sequencing, polymerase chain reaction, DNA fingerprinting and DNA markers.

**Genetic engineering of plants :** Transgenic plants, Methods of gene transfer – *Agrobacterium* – medicated and microprojectile, chloroplast transformation, intellectual property rights, ecological risks and ethical concerns.

**Microbial genetic manipulation :** Bacterial transformation, selection of recombinants and transformants, genetic improvement of industrial microbes.

**Genomics and proteomics :** High throughput sequencing, genome projects, bioinformatics, functional genomics, microarrays.

## 10. ZOOLOGY

**General Concepts :**

1. Levels of structural organization :
   Unicellular, colonial and multicellular forms. Prokaryotic and Eukaryotic cells. Levels of organization of tissues, organs & systems.
2. Acoelomata, Pseudocoelomata, Coelomata, Proterostomia and Dueterostornia.
3. Concepts of species and hierarchical taxa, biological nomenclature, classical methods of taxonomy of animals.

**Non-Chordata :**

1. General characteristics and classification of invertebrates up to class level.
2. Protozoa: Locomotion, Nutrition and Reproduction in protozoa, Protozoan diseases of man.
3. Porifera: Canal system in porifera, skeleton in porifera, Reproduction in sponges.
4. Coelenterata : Polymorphism, Metagenesis, coral formation,Etenophora.
5. Hemlinths: Common Helminthic parasites of Man – *Taenia solium, Schistosoma sp., Ascaris, Ancylostoma, Oxyuris, Loa, Trichinella, Strongyloides* – their life cycles. Parasitism and parasitic adaptations.
6. Annelida: Excretory system, Coelom formation, coelom and coelomoducts.
7. Arthropoda: Mouthparts of Insects, useful and harmful insects, Metamorphosis in insects. Apiculture and sericulture in India, crustacean larvae.
8. Mollusca: Respiritation, Torsion and De-torsion, pearl formation and Pearl industry.
9. Echinodermata: Echinoderm larvae, Water vascular system.