DETAILED SYLLABUS

Research Methodology

Group – A: General Research Methodology

1. Research hypothesis: Framing of hypothesis, types and validation.
2. Method of data collection and data management: Survey types and techniques in research, strengths and weaknesses of survey work; structure and types of questionnaire; Interview: Types and techniques; Observation: types and Importance.
3. Sampling techniques and measurement, reliability and validity of data. Types of sampling, methods of measuring validity, threats to reliability and validity.
4. Designing of research experiments; Experimental aims, Sampling design, Experimental design. Simple random sampling, Completely randomized design, Randomized block design, Trends, Analysis of pattern and process, Systematic sampling, Response surface, Regression analysis, Multiple regressions.
5. Research ethics, IPR, Patent and Biopiracy.
6. Paper and project report writing and presentation: significance of report writing, steps in report writing; layout of a research report; types of reports; concept of oral presentation; mechanics of writing a research report; precautions for writing research reports.

Group – B: (Research Methodology in Plant Sciences)

1. Laboratory discipline, safety and care, laboratory note book, experimental report, standard units of expression.
2. Isolation and culture of microbes, enrichment techniques, culture collection and resources, important preservation techniques.
3. Biochemical calculations. Normality, molarity, molality, percent and ppm solutions and their conversions.
4. Basic techniques in Genomics and Proteomics. Isolation and purification of RNA , DNA (genomic and plasmid) and proteins, different separation methods; analysis of RNA, DNA and proteins by one and two dimensional gel electrophoresis, isoelectric focusing gels; Blotting techniques: Southern and Northern; *in vitro* mutagenesis and deletion techniques, gene knock out in bacterial and eukaryotic organisms; protein sequencing methods, detection of post-translation modification of proteins; methods for analysis of gene expression at RNA and protein level.
5. Histochemical and immune-techniques: Antibody generation, western blot, immuno-precipitation, flowcytometry.
6. Biophysical methods: Analysis of biomolecules using UV/visible spectrophotometry, fluorescence, circular dichroism, NMR and ESR spectroscopy, structure determination using X-ray diffraction. Basic principles of paper, thin layer, column, high pressure liquid chromatography, gas chromatography.

7. Centrifugation techniques: Basic principles of sedimentation, high speed, ultra, density gradient centrifugation.
8. Cytogenetical techniques: Mitotic and meiotic chromosome preparations; Knowledge on pretreating; fixative and other potential chemicals and their use in cytogenetical techniques.
9. Plant tissue culture techniques: Plant tissue culture media preparation and culture of explants (embryo; shoot tips and nodal segments); Micropropagation via organogenesis and somatic embryogenesis; cell suspension culture; anther and embryo culture; determination of genetic fidelity (chromosome and molecular level) from plant tissue culture derived plantlets; analysis of secondary metabolites from plant tissue culture derived plantlets; encapsulation technique for artificial seed production; plant transformation system (demonstration).
10. Statistical concepts and uses of the following in biology, Measures, of central tendency (mean, Median and mode), Standard deviation and error, co-efficient of variation, T and Chi square test, Bivariate coefficient of correlation, Analysis of variance (ANOVA).
11. Mycology and Plant Pathological techniques: Isolation of pathogenic microorganisms, Culturing of macrofungi; Screening techniques for antimicrobial activity; metal tolerant/accumulating fungal species; Assay of lignolytic enzyme activity; Long-term storage of plant pathogens; Techniques used in mycorrhizal study.
12. Field and Herbarium Methods: Botanical Collections or Field work: Purpose of plant collection; kinds of field work; collection work: documentation.
13. Representation of biological data and data analysis features of MS Excel: Measures of central tendency, measures of dispersion, correlation, Z-Tests, F-Tests, and T-Tests; ANOVA - one-way and two way,
14. Important terms for understanding statistical interpretation: P-value, Mean, Standard deviation, Standard error, Residual plot, Correlation, F-test, R-squared.
15. Use of SPSS software; Posthoc tests, LSD, DMRT, Tukeys test, D2, Bonferroni,
16. Basics and essential of bioinformatics; concepts of bioinformatics, DNA and protein databases, tools and algorithms used in bioinformatics (BLAST, MEGA 6.0), preparation of Dendogram / Phylogenetic tree.; Molecular modeling and docking.

SUBJECT SPECFIFIC

Microbiology

1. Modern criteria of bacterial classification; Brief account of evolution of bacteria.

2. Microbial Diversity and Extremophilies: Principal modes of metabolic diversity: Phototrophic bacteria; Chemolithotrophic bacteria; and Extremophiles (thermophilic, halophilic, acidophilic and alkalophilic bacteria

3. Bacterial growth: Growth curve, growth factor, batch and continuous culture; synchronous culture, enrichment culture, diauxic growth.

4. Bacterial motility- Mechanism and regulation; chemotaxis; quorum sensing

5. Microbial Metabolism and fermentation: Outlines of biosynthesis of peptidoglycan and major unusual amino acids. Basic metabolic pathways: Entner-Doudoroff pathway, fermentation and Nitrogen metabolism.

6. Bacterial Genetics: Organization of genetic material in bacteria: chromosome and plasmid, Gene transfer mechanisms: conjugation, transformation and transduction, sexduction and complementation.

7. Operon: concept, inducible and repressible, positive and negative control, *Lac* operon, *trp*operon and *gal* operon.

Mycology

1. Origin and phylogeny of fungi; modern trends in classification.
2. Architecture of fungal cell, cell wall, membrane, cell organelles and cytoskeleton, nucleus and its division; biogenesis & protoplast technology; translocation in mycelia.
3. Asexual and sexual reproduction. Basic patterns of sexuality, heterothallism and parasexuality.
4. Diversity of somatic, reproductive and fruiting structures in different groups of fungi: Myxomycotina, Mastigomycotina (with special reference to sex hormones), Zygomycotina, Ascomycotina, Basidiomycotina and Deuteromycotina (with special emphasis on conidial ontogeny).
5. Fungal symbionts: lichens and mycorrhiza.
6. Fungi as animal parasites, mycoses of vertebrates: types and symptoms, insect fungus association.
7. Fundamentals of fermentation technology: Industrial production and purification of citric acid, alcohol and antibiotics (Penicillin).
8. Biodegradation and mycoremediation.

Phycology

1. Modern criteria of algal classification with emphasis on chloroplast ultrastucture, flagella and pigments.
2. Evolution and Biodiversity of algae: Evolution of algae at morphological and ultrastructural level. Algal diversity in different habitat and their conservation.
3. Phylogeny and evolution of algae.
4. Diversity of algal forms and habitats; Brief account of Glaucophyta, Dinophyta and Heterokontophyta.

5. Phytoplankton ecology: Importance of size, scale, types of phytoplankton, climate change impact.
6. Pigmentation, storage metabolites and toxins of algae.
7. Algal genome: structure and complexity.

Bryology

1. Broad outline of classification, Few important classification schemes (Proskauer, 1957; Davis et. al., 2006; Crandall-Strotler, 2009; Qiu et al., 2016); traditional and modern systems with reference to liverworts, hornworts and mosses, and evolutionary trends among Bryophytes.
2. Bryophyte origin and evolution.
3. Bryophyte ecology: substrate colonized by bryophytes, growth forms and life forms.
4. Bryophyte as site indicators-responses of bryophyte to environmental pollution, initial colonization and succession.
5. Bryophyte chemistry and cytology and their taxonomic implications.
6. Characteristics, affinities and systematic position of Sphaerocarpales, Takakiales, and Monocleales.
7. Brief idea on: fossil bryophytes, photoperiodism, apogamy and apospory, vegetative modes of reproduction, Peristome characters and their importance, Bryophyte conservation.

Pteridology

1. Outline of systematic treatment of Pteridophytes, current concepts on classification.

2. Early land plants; Protracheophytes and Rhyniophytoids; Lycophytina and Euphyllophytina; General characteristics and evolutionary significance of Zosterophyllopsida, Trimerophytopsida, Equisetopsida.

3. General characteristics of Polypodiopsida with evolutionary significance of existing orders: Zygopteridales and Coenopteridales; General characters of existing order of ferns.

4. Stomatal types and their development; evolution of stele; telome theory; types of spore, induction of spore germination; biochemical aspects of gametophyte differentiation; determination of femaleness in free sporingheterosporous plants.

5. Diversity of ferns in an ecological perspective; phytochemistry of pteridophytes; endangered and endemic pteridophytes and their conservation.

6. Polyploidy, apospory, apogamy, apomixis and hybridization.

Gymnology

1. Current concepts on classification of Gymnosperms.

2. Concept of progymnosperms and its evolutionary significance.

3. Brief account of extinct Cycadales and Coniferales with emphasis on evolutionary aspects.

4. Vegetative morphology and reproductive biology (pollination mechanism, embryogeny) of extant Cycadales, Coniferales, Ginkgoales, Taxales and Gnetales.

5. Economic importance and phytochemistry of important taxa, endangered and endemic taxa and their conservation.

Anatomy

1. Introduction to the history of plant anatomy and it's evolution- evidences from different fossils and different groups of plants, hypotheses, eta.

2. Basic Plant Cell Histology- Histology of Cell Contents, Plant Extracellular Matrix,etc

3. Basic Plant Cell Types- Apical Meristem; Vascular Cambium; Phellogen Epidermis; Guard Cells, etc. evolutionary significance.

4. Functional Tissue Systems- tissue types, function and organizations in root, stem, leaf, flowers and fruits, differences among - gymnosperms and angiosperms, monocots and dicots, etc., evolutionary significance.

5. Anatomical anomalies- both structural and functional.

Palaeobotany

1. Basic geological information related to palaeobotany: Sedimentary rocks; Taphonomy; dating of rocks: relative dating by fossils, absolute dating (radiometry); nomenclature and reconstruction of fossil plants; Stratigraphy; Basic concepts of continental drift and plate tectonics.

2. Appearance of Angiosperms: Evidence for the first angiosperms: leaves, flowers and pollen grains; place of origin and radiation.

3. Fossil: types and mode of preservation, conditions of preservations.

4. Applied palaeobotany: In academic and applied aspects: Fundamentals of palaeofloristics, palaeogeography, palaeo-ecology and palaeo-climatology.

Evolution

1. Introduction: Evolutionary Biology before Darwin, Darwin, after Darwin. Evolutionary synthesis. Fact and theory.

2. Biological diversity: Species and classification. Phylogenetic trees, reading and using trees. Tree of Life. The fossil record. Geological fundamentals. Phylogeny and the fossil record. Evolutionary trends. Rates of evolution. The geography of life. Major patterns of distribution. Historical biogeography, phylogeography.

3. Genetic diversity: Genes, genomes, mutations,karyotypes. Sources of phenotypic variation. Genetic variation in populations. Variation among populations.

4. Microevolution: Genetic drift, sampling, coalescence. Founder effects. Neutral theory ofmolecular evolution. Natural selection. Adaptation in action. Experimental studies. Levels of selection. Genetical theory of natural

selection. Fitness, modes and models of selection. Evolution of phenotypic traits, Conflict and co-operation. Species and speciation. Reproductive success. Co-evolution.

5. Macroevolution: Inferring phylogenies. Gene trees, species trees. Patterns of evolutionarychange. Adaptive radiation. Evolution and development.

Palynology

1. Palynology and its branches.

2. Spore and pollen morphology: polarity, symmetry, shape, forms of apertures and their functions; structure and sculpture of sporoderm, pollen wall evolution, NPC system.

3. Developmental changes of spore / pollen wall morphology.

4. Applied palynology: Application of neopalynology and palaeopalynology; melissopalynology; medical palynology; forensic palynology.

5. Microscopic techniques: Visualization of cells and subcellular components by light microscopy, phase contrast and confocal microscopy, resolving powers of different microscopes, microscopy of living cells, fluorescence microscopy, Electron microscopy, different fixation and staining techniques for EM. Image capturing and analysis – in brief.

Reproductive Biology

1. Historical account and modes of reproduction: An overview.

2. Gender expression in monoecious and dioecious plants.

3. Developmental biology of male and female gametophytes: Regulation of anther and ovule development, microsporogenesis and microgametogenesis, megasporogenesis and megagametogenesis.

4. Pollination: Anther dehiscence, self vs. cross pollination, pollination agencies, artificial pollination.

5. Pollination strategies in plants.

6. Pollen-pistil interaction and fertilization: In vivo and in vitro pollen germination, pollen tube growth and guidance, double fertilization, self-compatibility mechanisms, incongruity.

7. Embryogenesis: Polarity during embryogenesis, in-vitro fertilization, endosperm development, apomixis, polyembryony, somatic embryogenesis.

Cytology

1. Cytoskeleton: Microtubules and its organization, ultra structure of nucleus, nucleolus, and nuclear envelope, signal transmission through nuclear envelope; mitochondria- ultra structure, mt-DNA, and genetic code; chloroplast- ultra structure, and cp-DNA; peroxisome and endoplasmic reticulum – ultra structure and function.
2. Changes in chromosome number and structure: Polyploidy, aneuploidy, chromosomal rearrangements deletion, duplication, inversion, and translocation.
3. Chromatin structure: DNA-protein interaction, nucleosome morphology and higher level organization.
4. Chromosome organization: Structure of centromere and kinetochore, telomere and its maintenance; holocentric chromosomes; heterochromatin and euchromatin, position effect variegation.
5. Specialized Chromosomes: Polytene, lampbrush and B chromosome.
6. Techniques in the study of chromosomes and their applications: Karyotype concept, principle of chromosome banding technique, chromosome labelling, in situ hybridization, GISH and FISH techniques.

Genetics

1. Laws of inheritance: Mendel's Laws, concepts of dominance, segregation, independent assortment, deviation from Mendelian inheritance.
2. Non-Mendelian inheritance: Co-dominance, incomplete dominance, gene interactions, pleiotropy. Extranuclear inheritance: Basis and mechanism, role of organellar genes.
3. Linkage - types and detection, crossing over and chromosome mapping: Crossing over as the physical basis of recombination; molecular basis of recombination (Holliday model); chromosome mapping: three point test cross.Sex linked inheritance and sex-limited traits: Sex chromosomes and sex determination in plants, sex linked inheritance.
4. Quantitative inheritance: Concept, genes and environment heritability, penetrance and expressivity.
5. Concept of gene: Fine structure of gene, split genes, overlapping gene, pseudogene and cryptic genes and multi-gene family, concept of allele, multiple allele, pseudoallele. Genotype characterisation of plants – isolation of genetic matter, gene mapping, manipulation and genetic barcoding.
6. Population genetics: population, gene frequency in population, genetic equilibrium, Random mating population, Hardy-Weinberg Principle, barriers to gene flow and mechanism of speciation.

Molecular Biology

1. Gene structure, regulation and expression in eukaryotes: Biology of DNA and RNA; DNA forms, central dogma, central dogma reverse; Gene and promoter architecture, cistrons, regulatory sequences, enhancers and their mechanism of action, DNA replication; transcription - RNA polymerases, transcription factors, Introns, RNA splicing, alternative splicing, RNA stability - cap structure and function, polyadenylation; structure and function of different types of RNA, RNA transport.

3. Protein synthesis and processing: Genetic code; Translation mechanism and their regulation, translational proof reading, translational inhibitors, post- translational modification of proteins.

4. Mutation: Molecular basis of gene mutation, Transposon mutagenesis, Site directed mutagenesis, environmental mutagenesis, in vitro mutagenesis, DNA damage and repair mechanism.

5. Control of gene expression and gene silencing.

6. Cell multiplication and turnover: cell cycle and apoptosis

Developmental Biology

1. General Aspects: Novel features of plant growth and development; concepts of plasticity in plant development; analyzing plant growth.

2. Seed germination and Seedling growth: Mobilization of food reserves during seed germination; hormonal control of seed germination and seedling growth.

3. Shoot, Leaf and Root development: Organization of Shoot Apical Meristem (SAM); Control of cell division and cell-to-cell communication; Molecular analysis of SAM; Leaf development and differentiation; Organization of Root Apical Meristem (RAM); cytohistological zonation of SAM; Root hair and trichome development; cell fate and lineages.

4. Leaf development and phyllotaxy; transition to flowering.

5. Floral induction and development: Hormonal control; Inflorescence and floral determination; genetics of floral organ differentiation; homeotic mutants and floral development in *Arabidopsis* and *Antirrhinum;* sex determination, development of pollen grains.

6. Seed development and dormancy- Embryo and endosperm development; cell lineages during late embryo development; Seed maturation and dormancy; polyembryony; apomixis; apospory.

Plant Physiology

1. Plant water relationship: Concept of water potential and its components; water movement mechanism through plants; methods of water potential estimation.

2. Phloem translocation: Phloem loading and unloading, long distance transport, source and sink relationship.

3. Photosynthesis : Concept of photosystem and light harvesting mechanism, mechanism of electron transport, generation of proton gradient and ATP synthesis, CO2 concentrating mechanisms in plants (C1, C4, and CAM), regulation of C3, C4 and CAM cycles.

4. Structure, biosynthesis, cellular and molecular mode of action of auxin, gibberellins, cytokinin, ethylene, and abscisic acid; brief account of brassinosteroids and polyamines.

5. Senescence: Pattern of senescence, physio-biochemical changes during senescence; programme cell death in plants.

6. Sensory photobiology: Phytochrome: Structure and properties, phytochrome induced responses: physiological and biochemical, phytochromesignalling pathways; Cryptochrome: blue light sensitivity, structure, physio-biochemical responses.

7. Flowering physiology: Biochemical signaling and developmental pathways, ABC model, concept of florigen and antiflorigen, effect of day length and vernalization on flowering.

8. Stress physiology: Responses of plants to abiotic (water, temperature and salt) stresses; mechanisms of resistance and tolerance to abiotic stresses.

Biochemistry

1. Structure of atom, molecules and chemical bonds, Van der Waal's, electrostatic, hydrogen bonding and hydrophobic interaction; pH, buffer, indicator.

2. Bioenergetics: an overview; thermodynamic principles in biology; concept of free energy; reaction kinetics; colligative properties.

3. Respiration: Metabolic regulation of glycolysis, Kreb's cycle, ETC, and oxidative phosphorylation, pentose phosphate pathway, gluconeogenesis and glyoxylate cycle, photorespiration and cyanide resistant respiration.

4. General account of biomolecules: proteins, carbohydrate and lipids - structure and properties.

5. Conformation of proteins (Ramachandran plot, secondary, tertiary and quaternary structure; domains; motif and folds).

6. Enzymes: Enzyme properties, enzyme classification and nomenclature, enzyme activity, enzyme kinetics, enzyme inhibition. General account of coenzymes, isoenzymes, allosteric enzymes, ribozymes and abzymes.

7. Lipid metabolism: Biosynthesis and oxidation of fatty acids.

Bioinformatics

1. Introduction to Bioinformatics – History, scope and applications.

2. Database, primary, secondary and specialized databases; Nucleotide sequence databases - NCBI, EMBL, DDBJ; Protein sequence databases - SWISSPROT; Protein structure databases - DB, MMDB, CATH; Sequence alignment - Local and Global, use of BLASTn, BLASTp, etc.; Sequence alignment using - FASTA; Multiple sequence alignment - CLUSTAL W; phylogenetic analysis using MEGA; prediction of physical and chemical properties of proteins.

Plant Pathology

1. Historical and developmental aspects of plant pathology.

2. Production, liberation & dispersal of inoculum, inoculum potential, survival of pathogen in nature & its spread.

3. Brief account of disease epidemics, disease forecasting and predisposition.

4. Recognition mechanism and signal transduction during plant-pathogen interaction; Mechanism of penetration and the process of disease development, role of cell wall degrading enzymes and toxins.

5. Mechanism of disease resistance.

6. Genetics of host pathogen interaction.

7. Plant disease diagnosis utilizing molecular tools.

Environmental Biology

1. Basics of Environmental Biology: Basic concepts of environmental biology, major issues and challenges, Origin of earth, composition of atmosphere, lithosphere, hydrosphere, biosphere and natural resources,

2. Ecosystem structure: air, water, soil, primary producers, consumers and decomposers.

3. Ecosystem function : energy flow, food chains, food webs, ecological pyramids & biotic interaction, Ecosystem disturbance, resilience, decline & succession, Global environmental changes, Decline of biodiversity, its reason and consequences of loosing bio-diversity. Concepts of sustainable development, Ethics of stewardship, Scope of environmentally sound technologies.

3. Climate Change & Abatement Technologies: Greenhouse gases and global warming, Drought and desertification, Acid rain and abatement technologies, Ozone layer destruction and prevention, Technologies to minimize and combat climate change.

4. Environmental Pollution and Management : Types, major sources and effects of air pollutants, air borne diseases, Technologies for air pollution management; Types, major sources and effects of water pollutants, water borne diseases, Technologies for water pollution management; Types, major sources and effects of soil pollutants, Technologies for soil pollution management; Major sources of noise pollution, effects of noise pollution on health, Technologies for noise pollution management; Types, major sources and effects of radioactive pollutants, Air, water and noise quality standards.

5. Geoinformatics: Geographic Information Systems, Map Projections, Surveying, Understanding geographic data, Global Positioning Systems, Application of GIS and remote sensing in environmental monitoring and, management.

6. Environmental Monitoring Technologies: Meteorological monitoring technologies, Application of remote sensing for environmental monitoring, Vegetation mapping and monitoring of biodiversity,

Optical and Molecular Spectroscopy, Non-Optical Spectroscopes, Physical and Chemical Sensors, Chromatographic and Partition Techniques, Chemical sensors, Biosensors, Biological Methods of environmental monitoring: Microbial, Screening, DNA Probes, Bioassays.

7. Environmental Biotechnology: Basic techniques in genetic engineering: Nucleic acid hybridisation and polymerase chain reaction as sensitive detention methods, Introduction of clone genes into new hosts using plasmid and phage vector systems. Expression of genes in new host, Use of micro-organisms in waste treatment and methane production, Production of microbial enzymes: cellulase, proteases, amylases, Alcohol and acetic acid production, Microbial leaching of low grade mineral ores Molecular probes for organisms in mines and mine tailings, Biodegradation of petroleum pollutants, Biofiltration technologies for pollution abatement, Genetically engineered microbes and environmental risk.

Plant Systematics & Plant Biogeography

1. Plant Systematics: Definition, steps, categories, methods, relationship with classical taxonomy; aims and scope of taxonomy, history and phases of taxonomy.

2. Data sources: Concepts of character, relevance of phytochemistry, ultra structure and molecular taxonomy; Numerical taxonomy.

3. Resources in Plant Systematics: Plant identification, nomenclature; collection and documentation; functions of field, herbarium, botanical gardens, flora / monograph.

4. Fundamentals of Taxonomy: Taxonomical hierarchy; species concept; principles and rules of ICN ((including fossils and cultivated plants); addition and alteration of latest code; priority of publication and limitations; effective and valid publication; author citation; changes and rejections of names; concept of biocodes and phyllocodes.

5. Major systems of classification: History of angiosperm classification; comparison of major systems of classification; broad outlines of Angiosperm Phylogeny Group (APG) IV, 2016, basal angiosperms, newly introduced orders, merits and demerits.

6. General survey of the following orders with salient features (APG IV): Magnoliales, Asparagales, Arecales, Liliales, Poales, Zinziberales, Cucurbitales, Fabales, Rosales, Malphigiales, Malvales, Caryophyllales, Gentianales, Solanales, Lamiales, Apiales, Asterales.

7. Phylogenetic taxonomy: Basic principles; species and speciation; heterobathmy, polarity and morphocline; anagenesis and cladogenesis; plesiomorphy, symplesiomorphy, apomorphy, synapomorphy; parallelism and convergence; monophyly, paraphyly, polyphyly; polarizing characters of homology, homoplasy and problems of homoplasy; adaptive radiation, microevolution: theory and concepts; macroevolution inferring phylogenies.

8. Plant Biogeography: Basic concept and scope; history of biogeography in India; geological formation and plant community; effect of climate on plant vegetation; edaphic profile and plant adaptation; phytogeographical regions of India; relation between cladistics and biogeography.

Pharmacognosy

1. Introduction, scope, classification and pharmacological action of plant drugs, Pharmacopoeias: Definition and examples.

2. Classification of plant drugs: Morphological and chemical; brief idea about different drug plants producing carbohydrates, alkaloids, glycosides and other secondary metabolites.

3. Secondary metabolites: Secondary metabolites and their classification; their ecophysiological functions. Overview of terpenoidal, alkaloidal, and phenolic metabolites and their biosynthesis pathways.

4. Recent advances in pharmacognosy: With special reference to anticancer, antidiabetic, hepatoprotective, anti-inflammatory, hypolipidemic, immunomodulatory drugs.

5. Concise account of macro and micro morphological features, constituents, and uses of following plants: *Atropa belladona, Catharanthus* spp., *Cephalis ipecacuenha*, *Cinchona* spp., *Datura stramonium*, *Digitalis purpurea, Holarrhena, Rauvolfia, Strychnos*.

6. Volatile oils: Composition, volatile oil yielding plants, production techniques, uses in aromatherapy and as drugs, brief account of rose oil, eucalyptus oil, lavender oil and garlic oil.

7. Resins: classification, brief outline of different types resins: Acaroid, amber, Canada balsam, balsam of Tolu, Rosin and rosin esters and their economic aspects.

8. Quality control of plant drugs: Concept of quality control, sources of variation, quality control of raw materials and finished products, documentation concepts of statistical quality control.

Analytical Techniques

1. Extraction of metabolites: solid-liquid, liquid-liquid phases; bioassay guided fractionation.

2. Chromatographic techniques for purification and characterization: Basic principles of paper, thin layer, column, high pressure liquid chromatography, gas chromatography.

3. Biophysical methods for molecular characterization: Analysis of biomolecules using UV/visible spectrophotometry, IR spectroscopy, fluorescence, circular dichroism, NMR and ESR spectroscopy, structure determination using X-ray diffraction.

Ecology

1. The Environment: Physical environment; biotic environment; biotic and abiotic interactions.

2. Habitat and niche: Concept of habitat and niche; niche width and overlap; fundamental and realized niche; resource partitioning; character displacement.

3. Population ecology: Characteristics of a population; population growth curves; population regulation; life history strategies (r and K selection).

4. Species interactions: Types of interactions, interspecific competition, herbivory, carnivory, pollination, symbiosis.

5. Community ecology: Nature of communities; community structure and attributes; levels of species diversity and its measurement; edges and ecotones.

6. Ecological succession: Types and mechanisms in succession; concept of climax.

7. Ecosystem: Structure and function; energy flow and mineral cycling (CNP); primary production and decomposition.

8. Biogeography: Major terrestrial biomes; biogeographical zones of India.

Conservation Biology

1. Concepts, plant diversity in India, mega diversity centres, hotspots and hottest hotspots (with special reference to India); IUCN categories (rare, vulnerable, threatened and endangered plants); Red data book, CITES and appendices.

2. In situ conservation: protected area network of India: biosphere reserves, wild life sanctuaries, and National Parks - a general concept with examples.

3. Ex situ conservation: Strategy, methods of conservation, cryopreservation: DNA bank / seed bank.

4. Biodiversity: assessment, conservation and management, biodiversity act of India and related international conventions. Sustainable development, natural resource management in changing environment. Molecular ecology, genetic analysis of single and multiple population, phylogeography, molecular approach to behavioural ecology, conservation genetics.

Biotechnology

1. Brief history of plant tissue culture, Cellular totipotency, Basic requirements for tissue culture laboratory, formulation of tissue culture medium, growth regulators, steps of tissue culture starting from culture initiation to hardening.
2. Micropropagation: methods and stages, advantages, disadvantages and application.
3. Organ culture, callus culture, cell suspension culture; haploid culture – technique and applications.
4. Protoplast culture and somatic hybridization – isolation technique, fusion, selection of hybrid cells, homokaryons and heterkaryons, regeneration – symmetric and asymmetric hybrids, cybrids, application.
5. Somatic embryogenesis – direct and indirect, role of growth regulators, applications, artificial seeds.
6. Plant genetic engineering: gene delivery systems in plants – direct gene transfer (biolistic and other methods) and indirect (vector mediated methods using *Agrobacterium* system).
7. Recombinant DNA technology: restriction enzymes, cloning using vectors (plasmids, cosmids, phagmids, BAC, YAC, transposable elements, DNA sequencing, PCR, Concepts of DNA chips and microarrays.
8. Molecular marker techniques: RAPD, RFLP and AFLP.
9. Intellectual property rights (IPR); Patents, trade secrets, copyright, trademarks; Plant genetic resources; Plant varietals protection and registration; WTO & TRIPPS; Patenting of biological material; Bio-safety and containment practices and Food-safety of GMO crops.

Biostatistics

1. Sampling methods- concept of sampling population, measures of central tendency and dispersal: determination of mean, mode, median, variance, standard deviation and standard error.
2. Rules of probability (Binomial, Poisson and normal), Null-hypothesis, Tests of significance: chi-square test, t-test (student and paired t-test), and F-test.
3. Regression and correlation, Analysis of variance and co-variance.
4. Design of experiments - RBD, latin square, split plot.
5. Difference between parametric and non-parametric statistics; confidence interval.

Crop Protection & Improvement

1. Theories related to crop and pathogen interaction; historical perspective and evolutionary significance.

2. Concept of Crop Phenology & its significance in crop production. Agroclimaticfactors affecting crop phenology. Weather based estimation of phonological stages.
3. Concept of GDD, HTU, PTU, T1R & their applications in agriculture.
4. Influence of surface features on microclimate. Profiles of radiation, temperature, vapour, wind and CO_2 concentration within plant canopy and their significance in crop growth and production. Process of heat transfer in soils. Relationship between soil and air temperature. Influence of soil temperature in crop growth and production. Effect of weather parameters on crop production. Weather hazards important for agricultural activities- Flood, drought, cold wave, heat wave, hail storm, thunderstorm, frost, cyclone, their time and frequency of occurrence.
5. Crops and their growth stages critical to different weather hazards. Crop protection measures against weather hazards-Wind break and shelter belts, protective irrigation, shading and mulching, artificial rain making and other management options. Concept of contingent crop planning in relation to weather hazard. Weather forecasting for agriculture. Types of forecasting-Short, medium and long range. Methods of weather forecasting-synoptic, statistical and numerical approaches.
6. Crop improvement through plant biotechnology and its relevance in agriculture; Definitions, terminologies and scope in plant breeding. Tissue culture- History, callus, suspension cultures, cloning; Regeneration; Somatic Embryogenesis; Anther culture; somatic hybridization techniques; Meristem, ovary and embryo culture; cryopreservation.
7. Molecular mapping and tagging of agronomically important traits. Statistical tools in marker analysis, Marker-assisted selection for qualitative and quantitative traits; QTLs analysis in crop plants, Gene pyramiding. Marker assisted selection and molecular breeding; Genomics and genoinformatics for crop improvement; Integrating functional genomics information on agronomically/economically important traits in plant breeding; Marker-assisted backcross breeding for rapid introgression.
8. Production of transgenic plants in various field crops: cotton, wheat, maize, rice, soybean, oilseeds, sugarcane etc. Commercial releases. Biotechnology applications in male sterility/hybrid breeding, molecular farming. MOs and related issues (risk and regulations); GMO.

Virology

1. Viruses and acellular microbes: Distinctive properties of virus, Nomenclature and classification (ICTV).
2. Morphology and ultra-structure of virus, capsid and their arrangements, types of envelops and their composition; cultivation, assay of virus.
3. Viral genome, their types and structure; virus movements and transmission; viral replication: lytic and lysogenic and their regulations. Virus related agents (viriods and prions).

Immunology

1. Immune system: History of immunology, innate and acquired immunity, humoral and cell mediated immunity, organ and cells involved in immunity, T cell and B cells.

2. Antigens: Characteristics and types, structure and functions, adjuvants. Overview of Vaccines.
3. Immunoglobulins: Types, structure and properties. Different classes of Igs; primary and secondary immune response; lymphocytes and accessory cell; Humoral and cell mediated immunity; MHC; mechanism of immune response and generation of immunological diversity.
4. Genetic control of immune response; Effector mechanisms; applications of immunological techniques.

Molecular Cytogenetics & Biotechnology (Part-I)

1. Chromosomal staining and banding techniques; concepts of karyotype and idiogram; structure, packaging and properties of DNA; chromosomal DNA content; repetitive, satellite and unique DNA sequences, C-value paradox.
2. Dosage compensation- concepts and molecular mechanism.
3. Genetic control of floral development and pigmentation with special references to MADS box and different types of pigment formation in maize as well as flower colour inheritance in different plants.
4. Male sterility- concept, induction, mechanism, types and maintenance of male sterile lines.
5. Cancer- genetic basis, protooncogenes, oncogenes, tumor suppressor genes, role of tumor suppressor proteins, pathways of cancer development, apoptosis.
6. DNA replication- mechanisms in linear and circular DNA molecules, machinery in prokaryotes and eukaryotes, replication of nucleosides, role of telomerase in replication and its role in aging.
7. Regulation of gene expression in eukaryotes- Various motifs involved in DNA-protein interaction during transcription, chromatin remodelling.
8. Quantitative and evolutionary genetics- traits controlled by multiple loci, detection with molecular markers and QTL mapping, quantitative inheritance in plants, Hardy-Weinberg equilibrium: factors and determination.
9. RNA biology- Transcriptional mechanism and control strategies, processing of different categories of RNAs (including small non coding RNAs, mechanism of RNA interference and gene silencing, application of RNAi in crop improvement.
10. Genomics and Proteomics- concepts and applications.

Molecular Cytogenetics & Biotechnology (Part-II)

1. Cell signalling- general principles, cell surface receptors, signalling through G protein couple receptors, signal transduction pathways and second messengers.
2. Membrane transport- membrane proteins, principles of membrane transport, carrier proteins and active membrane transport, ion channels and electrical properties of membranes.
3. Eukaryotic cell cycle- overview, biochemical and genetic approaches, cell cycle control in yeast.
4. Plant Tissue Culture- infrastructure of tissue culture laboratory; composition of specialised media: for callus culture, microshoot culture, root culture, regeneration of cryptograms, micropropagation of woody plants and orchids.

5. Organogenesis- developmental sequences, mechanism of action of plant growth regulators, cell cycle control in morphogenesis; Somatic embryogenesis- structural and developmental ontogeny, physiological and biochemical aspects of somatic embryogenesis, molecular markers and genes for somatic embryogenesis, gene expression and signal transduction, regulation of somatic embryogenesis, synthetic seed production.

6. Micropropagation- stages, use of molecular markers in study of genetic fidelity of micropropagated plants.

7. Somaclonal and gametoclonal variation-concept, isolation and characterization of somaclones, molecular basis of somaclonal variation, advantages of somaclonal variation over induced mutations and application.

8. Genetic manipulations in plants: Strategies and methods of genetic manipulations in plants; *Agrobacterium*-mediated gene transfer; Genetic elements and engineering of Ti and Ri plasmids; Direct gene transfer – electroporation, particle bombardment and other alternative methods; Selectable markers and reporter genes; chloroplast transformation; Molecular farming, benefits and risks.

9. Application of transgenic techniques in plants: Transgenic crops to develop biotic and abiotic stress resistance, genetic engineering for modification of flower color, fruit ripening, and senescence, GM crop for nutritional quality quantity.

10. Tools in plant biotechnology: Restriction endonucleases, construction of different types of cloning vectors, reconstruction of chimeric DNA, preparation of molecular probe, labelling of probe, application of radio isotope, X-ray diffraction and its application, spectroscopic and electrophoretic methods, macromolecular sequencing, design and manipulation of plant system-based drugs (an outline idea).

Plant Physiology, Biochemistry & Molecular Biology (Part-I)

1. Membrane transport: pumps, carriers and channels: an over view, membrane potential.

2. Cell wall: Structure, Biogenesis and Expansion.

3. Ecological considerations of photosynthesis: Energy harvest and carbon dioxide fixation.

4. Plant movements: Gravitropism - sensing mechanism and reaction mechanism; Phototropism - fluence response curve, photoreceptor and mechanism.

5. Sensory photobiology: Phytochrome - structure, physico-biochemical properties and mode of action, phytochrome gene family and their specializations; Cryptochrome and blue light responses, physiological activities, xanthophyll cycle.

6. Stomatal physiology and water status maintenance: Structural architecture of stomatal cell wall; opening and closing mechanism of stomata in mesophytes and xerophytes - current concepts, role of ABA.

7. Plant growth and regulation: Gene expression during embryogenesis; role of transcription factors and genes during plant development; Auxin mediated growth; Brassinosteroids, polyamines, jasmonic acid, salicylic acid: chemistry, metabolism and mode of action.

8. Senescence and Programmed cell death in plants: Overview of senescence; factors influencing the senescence; metabolic programming during senescence and cell death.

9. Fruit development and ripening: Physiology and biochemical changes during ripening, molecular biology of ripening associated genes and their expression.

10. Signaling in plants: Overview of receptors and G- proteins phospholipids signaling; Role of cyclic nucleotides calcium-calmodulin cascade; Diversity in protein kinase and phosphates specific signaling mechanism - plants sucrose sensing mechanism; Stress signaling and role of specific transcription factors; ROS generation and scavenging mechanism; Salinity stress and osmotic adjustment: SOS pathway, heat shock proteins, anti-freeze proteins; Stress induced genes and proteins; Genetic engineering of stress tolerance.

Plant Physiology, Biochemistry & Molecular Biology (Part-II)

1. Nitrogen metabolism: Nitrate and ammonia assimilation and their control; Nitrogenase - structural composition, types and mechanism of action.

2. Nucleotide biosynthesis: Purine and pyrimidine biosynthesis, de novo and salvage pathways; regulation and degradation.

3. Pigments: General overview; chlorophyll biosynthesis; Metabolic engineering of carotenoid pathway.

4. Macromolecular characterization: Purification, structure determination and sequencing of Proteins, Carbohydrates and Nucleic acids; Brief overview of Genomics and Proteomics.

5. Genome maintenance: Structure of DNA and RNA, types and modern concepts; Nucleosome model, higher order chromatin structure, nucleosome remodeling and assembly; DNA polymerases and repair mechanism; Homologous recombination - mechanism and consequences, site-specific recombination, transposition, principle classes of transposable elements.

6. Genome expression and protein biology: RNA polymerases and transcription cycle, RNA splicing and editing; mRNA transport; Genetic code - basic principles and exceptions; Proteins synthesis; protein folding and assembly, ubiquitin mediated degradation; Protein sorting and vesicular trafficking; Concept of amino acids biosynthesis.

7. Gene regulation: Points of regulation, structural and chemical regulation; Operon concept - Lactose operon, tryptophan operon; Post transcriptional gene silencing, concept of RNAi - miRNA and siRNA; Post translational regulation, ribozymes; Genetic imprinting.

8. Purification and Assay of Enzymes: Mechanism of enzyme action (Chymotrypsin, Lysozyme and Lactate Dehydrogenase); Active site mapping; Regulation of enzyme activity; Enzyme mutations; Applications of enzymes.

9. Genetic engineering: Principles and methods of Genetic Engineering; DNA cloning, cloning vectors, restriction endonucleases, rDNA technology; Gene libraries and cDNA libraries; Polymerase chain reaction and its variants; DNA fingerprinting, Restriction mapping; Direct and indirect gene transfer methods.

10. Techniques: Horizontal and Vertical gel electrophoresis; DNA and RNA hybridization; radioisotope technology; tools of analyzing DNA-protein, RNA-protein and protein-protein interaction; microarray technique; DIGE; GFP tagging.

Microbiology and Microbial Biotechnology (Part-I)

1. General Microbiology:Enrichment, pure culture, identification, Cultivation, preservation of microorganisms.
2. Microbial systematics, evolution and biodiversity:Classification of bacteria: GC content analysis and nucleic acid hybridization, 16S rRNA sequence based phylogeny. Archaebacteria. Origin of life: universal ancestor, origin of eukaryotic cells
3. General account:Mycoplasmas; Gliding bacteria; Actinomycetes
4. Growth and growth control: Counting viable but non-culturable prokaryotes; Quorum sensing; Growth control by physical exclusion, heat; radiation and chemicals
5. Genetics:Genetic code- its nature and deciphering; Transcription; Post-transcriptional RNA processing; Translation; Plasmid biology -types; detection, purification and replication; Genetic engineering -splicing of DNA, insertion of DNA into vector, detection of recombinant molecules, Polymerase chain reaction and its applications; Expression of cloned genes.
6. Immunology: Cells and organs of the immune system; Immunoglobulin classes; Formation and structure of Immunoglobulin G; Polyclonal and monoclonal antibodies; Antibody-antigen reactions; Immunodiagnostics; Immune diseases (Hypersensitivity; Autoimmune diseases)
7. Chemotherapy:General principles; classification of antibiotics; Chemistry, mode of actions and antimicrobial spectra of antibacterial and antifungal antibiotics; Mechanism of antibiotic resistance in prokaryotes.

Microbiology and Microbial Biotechnology (Part-II)

1. Viral interference: Characteristics of interferons; Induction and regulation of interferon production; Mechanism of interferon action; Protective role and applications in interference.
2. Microbial diseases: Pathogenesis, laboratory diagnosis and treatment of tuberculosis and influenza, syphilis and acquired immunodeficiency syndrome, malaria, staphylococcal food poisoning , cholera , and candidosis ; Emerging and resurgent infectious diseases
3. Microbiology of water: Microbiological examination of water, indicator microorganisms, disinfection, and purification processes.
4. Pollutants and microbial interactions: Origin and dispersal of pollutants, types of pollutants-pesticides, hydrocarbons, surfactants, synthetic polymers, metals, monitoring pollutants. Biodegradation of representative pollutants and xenobiotic compounds.
5. Food and Industrial Microbiology: Recent developments in food and industrial microbiology– Fermentation, fermented foods, fermenter design and growth processes, food spoilage, methods of food preservation; Microbes in recovery of metal (bioleaching) and oil; Cell and enzyme immobilization, microbial enzymes of industrial interest; Novel medicines from microbes.
6. Agricultural Microbiology: Agriculturally important microorganisms; Biological nitrogen fixation; Mycorrhizae, microbial mineralization, Biocontrol of plant diseases, Plant growth promoting rhizobacteria (PGPR).

Environmental Biology (Part – I)

1. **Basics of Environmental Biology:** Basic concepts of environmental biology, major issues and challenges, Origin of earth, composition of atmosphere, lithosphere, hydrosphere, biosphere and natural resources, Ecosystem structure : air, water, soil, primary producers, consumers and decomposers, Ecosystem function : energy flow, food chains, food webs, ecological pyramids & biotic interaction, Ecosystem disturbance, resilience, decline & succession, Global environmental changes, Decline of biodiversity, its reason and consequences of loosing bio-diversity. Concepts of sustainable development, Ethics of stewardship, Scope of environmentally sound technologies.
2. **Climate Change & Abatement Technologies:** Greenhouse gases and global warming, Drought and desertification, Acid rain and abatement technologies, Ozone layer destruction and prevention, Technologies to minimize and combat climate change
3. **International Agreements on Environment:** Global organizations working on ecology and environmental issues, United Nations Conference on Human Environment - UNCHE (Stockholm, 1972)., United Nations Conference on Environment and Development - UNCED (Rio de Janeiro, 1992), World Summit on Sustainable Development - WSSD (Johannesburg, 2002), Treaties/protocols related with environment
4. **Environmental Pollution and Management :** Types, major sources and effects of air pollutants, air borne diseases, Technologies for air pollution management; Types, major sources and effects of water pollutants, water borne diseases, Technologies for water pollution management; Types, major sources and effects of soil pollutants, Technologies for soil pollution management; Major sources of noise pollution, effects of noise pollution on health, Technologies for noise pollution management; Types, major sources and effects of radioactive pollutants, Air, water and noise quality standards.
5. **Geoinformatics:** Geographic Information Systems, Map Projections, Surveying, Understanding geographic data, Global Positioning Systems, Application of GIS and remote sensing in environmental monitoring and, management.
6. **Environmental Monitoring Technologies:** Meteorological monitoring technologies, Application of remote sensing for environmental monitoring, Vegetation mapping and monitoring of biodiversity, Optical and Molecular Spectroscopy, Non-Optical Spectroscopes, Physical and Chemical Sensors, Chromatographic and Partition Techniques, Chemical sensors, Biosensors, Biological Methods of environmental monitoring: Microbial, Screening, DNA Probes, Bioassays
7. **Environmental Biotechnology:** Basic techniques in genetic engineering: Nucleic acid hybridisation and polymerase chain reaction as sensitive detention methods, Introduction of clone genes into new hosts using plasmid and phage vector systems. Expression of genes in new host, Use of micro-organisms in waste treatment and methane production, Production of microbial enzymes: cellulase, proteases, amylases, Alcohol and acetic acid production, Microbial leaching of low grade mineral ores Molecular probes for organisms in mines and mine tailings, Biodegradation of petroleum pollutants, Biofiltration technologies for pollution abatement, Genetically engineered microbes and environmental risk

8. **Ecological Engineering:** Ecological engineering as a tool for restoration of degraded ecosystems, Ecology of Disturbed Ecosystems: disturbance and its impact on the structure and functioning of terrestrial and aquatic ecosystems., Concepts and strategies of restoration, Biological and biotechnological tools of restoration, Restoration of biological diversity: Acceleration of ecological succession, reintroduction of biota, Degradation and restoration of Forests ecosystems, Degradation and restoration of grassland ecosystems, Degradation and restoration of aquatic ecosystems, Degradation and restoration of wetlands, Restoration of wastelands and degraded soils: Restoration of contaminated soils and soil fertility, mine spoil restoration
9. **Natural Hazards and Chemical Hazards & Management Technologies:** Extent and nature of natural hazards, Nature and extent of flood; environmental effects of flooding; flood mitigation methods, Landslides: causes, prevention and correction, Coastal hazards: tropical cyclone and tsunamis; coastal erosion; sea level changes and its impact on coastal areas, hurricanes and tsunami, Earthquakes: causes, intensity and magnitude of earthquakes, geographic distribution of earthquake zones, nature of destruction, protection from earthquake, Volcanism: nature, extent and causes of volcanism, geographic distribution of volcanoes, volcanism and climate, Disaster management Technologies: pre-disaster phase, actual disaster phase, post-disaster phase, Technological assistance for disaster management, Relief camps, organization, camp layout, food requirement, water needs, sanitation, security, information administration, Role of NGOs in disaster management Toxicity of chemicals and its dose effect relationships, Chemical hazards in air, water & soil and remedial measures, Monitoring and control of chemical hazards, Characteristics and hazards of radioactive materials, dispersion of radioactive materials, Risk assessment techniques for accidental release of toxic and inflammable materials, Occupational health hazards: Silicosis, asbestosis, bronchitis, heart disease, nasal cancer, Industrial chemical hazards and safety measures, Biochemical effects of toxic heavy metals, pesticides, carcinogens, mutagens and teratogens, Food adulteration, contaminations and related hazards, Handling and transport of hazardous materials, environmental safety, risk management and emergency preparedness**.**

Environmental Biology (Part – II)

1. **Socio-economic Dimensions of Environmental Management:** Population explosion and social factors affecting development - poverty, affluence, education, employment, child marriage and child labour, Environment and human health, human rights, value education, women and child welfare, Impact of development on environment - changing patterns of land use, land reclamation, deforestation, resource depletion, pollution and environmental degradation, Basic concepts of sustainable development and social environmental issues, Community participation and capacity building programmes for sustainable socio-economic and ecological development,
2. **Waste Management Technologies:** Sources of waste, types and characteristics, Sewage disposal and its management, Solid waste disposal, Biomedical waste handling and disposal, Nuclear waste handling and disposal, Waste from thermal power plants, reuse and disposal, Waste minimization in industries, recycling and disposal technologies, Role of Microbes in waste minimization, Bio-chemistry of anaerobic fermentation and design of biogas systems, Application of phytoextraction and biofilteration techniques for waste management

3. **Air Monitoring and Management:** Basic principles of air pollution management, Ambient concentrations of air pollutants and trace gases, Air pollution and human health, Vehicular pollution, monitoring and abatement technologies, Meteorological parameters and dispersal of air pollutants, Air pollution control equipments, Control of particulate emission, Control of sulphur oxide and nitrogen oxides, Indoor air pollution and its control, Biological abatement of air pollution
4. **Water Management:** Global distribution of water, hydrological cycle and water balance on earth, Physico-chemical and biological properties of fresh water and water quality standard, Major sources of water pollution and its effect on surrounding water bodies, Effects of water pollutants on primary productivity of water bodies, Treatment technologies for domestic and industrial waste waters , Biological treatment of waste waters, Ozonization of secondary treated waste water, Ground water resources and its management, Water management strategies: rain water harvesting, artificial recharging of ground water and use of domestic and industrial waste waters, Watershed development, river linking and hydro power projects
5. **Mining Environment & Management:** Mining types and major environmental issues, Classification and properties of rocks, Classification and properties of minerals, Metallic and non-metallic mineral deposits, Geological and geographical distribution of mineral resources, Importance of mining and mineral resources, Impact of mining activities on health, Mine waste disposal and related problems, Mitigation technologies for mining related environmental problems, Restoration of mined areas
6. **Bio-resource Management Technologies:** Status and strategies for bioresource management, Sustainable exploitation and development, Forest resources management, social forestry and agro forestry, Grassland management, Cropland Management, Freshwater bioresource management, Marine bioresource management, Wetlands and estuary bioresource management, Microbial resource management, Wildlife management
7. **Environmental Legislation & Impact Assessment:** Powers and functions of Central & State pollution control boards, Duties and responsibilities of citizens for environmental protection, Important legislations related with environment: Wildlife Protection Act 1972, The Water (Prevention and Control of Pollution) Act 1974. Prevention and Control of Air Pollution Act 1981, Forest Conservation Act 1981, Environment (protection) Act 1986, Hazardous waste (Management and Handling) Rules, 1989, Bio-Medical Waste (Management and Handling) Rules, 1998, Environmental Impact Assessment (EIA), Environmental impact statement (EIS), Environmental management plan (EMP) and Environmental clearance for establishing industry, Cost benefit analysis, Environmental audit, ISO 14000 standards and certification.
8. **Noise Pollution & Abatement Technologies:** Noise pollution sources, Ambient noise level and its monitoring, Noise standards, Biological and behavioural effects of noise pollution, Noise pollution control technologies: physical and biological approaches
9. **Technologies for Restoration of Degraded Soils:** Physico chemical and biological properties of soil, Soil forming factors and soil development, Land use classification, Soil Erosion, factors affecting erosion, Principles and methodologies for soil conservation and restoration
10. **Biodiversity Conservation:** Biodiversity trends, diversity gradients and related hypotheses methods for monitoring biodiversity trends, Mega diversity zones and hot spots, Biodiversity valuation, goods and services

provided by biodiversity, Threats to biodiversity, major causes, extinctions, vulnerability of species to extinction, IUCN threat categories, Red data book, Principles and strategies of biodiversity conservation

11. **Environmental Modelling:** Basic concept of environmental modelling, its scope and limitations, Air quality modelling, Surface and ground water quality modelling, Modelling of hazardous substances, Modelling for landscape and urban planning.

Reproductive Biology of Angiosperms (Part-I)

1. **Modes of Reproduction**: An overview
2. **Flower development**: Regulation of floral architecture and diversification; Floral organogenesis; Pollination regulation of flower development.
3. **Male gametophyte**: Sporophyte-gametophyte interaction during micro- and megasporogenesis; interaction of mitochondrial and nuclear genes; male specific cytokinesis; tapetal development and pollen-coat formation; asymmetric division, cell fate and polarity; sperm dimorphism; male germ unit: cytology and 3-d structural organization; pollen biotechnology; manipulation of sperm cells; male-sterility; induction; mechanism of action and breeding; transformation of pollen; embryogenic development of pollen grains.
4. **Female gametophyte**: Regulation of pistil and ovule development; megasporogenesis and megagametogenesis: developmental pathways, gene function and organization.
5. **Pollen-pistil interaction and double fertilization**: Pollen tube guidance; recognition and rejection reaction, barriers to gene flow; signal transduction at the level o f stigma style and ovules, double fertilization: origin, mechanism and *in vitro* fertilization; preferential fertilization; pistil activation and ovule penetration.
6. **To exemplify the use of phase contrast and fluorescence microscopy in plant biology** by studying phase objects and autofluorescent specimens or those stained with fluorochromes.
7. **Immunotechniques:** Immunoprecipitation, Immunoassays, Immunoelectrophoresis, Monoclonal and hybridoma technology, FRET and FRAP.

Reproductive Biology of Angiosperms (Part-II)

1. **Plant-pollinator interactions and breeding systems**: Plant-pollinator interaction: floral display, attractants and rewards, pollen load, temporal details and foraging behaviour, pollinator and pollination efficiency, physicochemical aspects of pollination; pollination energetics, gene flow, applied pollination ecology; phenology; mating systems: diversity and quantitative estimation; differential reproductive success; resource allocation; pollen:ovule ratio; sibling rivalry, ovule abortion.
2. **Pollination ecology and impacts of climate change:** Case studies.
3. **Sexual incompatibility**: Genetic basis of sexual incompatibility, Barriers to fertilization, Physiology and biochemistry of incompatibility, Molecular mechanisms of self-incompatibility, Biological significance of incompatibility, Methods to overcome incompatibility.

4. **Fruit biology:** Development biology and diversity of fruit types, fruit abortion in relation to resource allocation, dispersal and gene flow.
5. **Seed biology:** Embryogenesis and embryonic pattern formation; endosperm development and differentiation; ultrastructure and cytology; seed development: pattern, regulation of gene expression and imprinting; agamospermy and parthenocarpy, pseudogamy and autonomous development of endosperm; Embryo and endosperm culture, synthetic seeds.
6. **Introduction to molecular markers**: RAPD, AFLP, RFLP, ISSR, SSR, SNPS &SCoT, Use of markers for genetic diversity studies, Assessment of mating pattern through molecular markers.
7. **Experimental and applied embryology**: Tissue culture techniques, Haploid production, Androgenesis, Gynogenesis, Haploid culture through Distant Hybridization, Embryo culture, Nucellus culture, Ovule and seed culture, Effect of young seeds on fruit growth, Parthenocarpy, Genetic transformation in plants.
8. **Role of reproductive biology in conservation of plants:** Case studies.