

New Syllabus for Post Graduate Studies (M. Sc.) in Botany

(w.e.f. the academic session 2017 – 2018)

*Includes Interdisciplinary Courses (IDC) as part of Choice
Based Credit System (CBCS)*



**Department of Botany
Raiganj University**

Raiganj University

New Syllabus for P. G. Studies (M. Sc.) in Botany

Duration: 2 years (Four Semesters); Total Marks -1600; Total Credit - 128

Semester I

Course/ Paper	Name of the Course	Marks			Credit	Hours		
		Class Test	Final	Total		CT	L	Total
Theoretical								
SI-BOT-1/T	Biochemistry and Molecular Biology of Plants	20	55	75	6	3	57	60
SI-BOT-2/T	Mycology and Plant Pathology	20	55	75	6	3	57	60
SI-BOT-3/T	Cytology and Genetics	20	55	75	6	3	57	60
SI-BOT-IDC1	Inter Disciplinary Course (IDC)-I*	30	70	100	8	5	75	80
Practical								
SI-BOT-4/P	Biochemistry and Molecular Biology of Plants			25	2			55
SI-BOT-5/P	Mycology and Plant pathology			25	2			55
SI-BOT-6/P	Cytology and Genetics			25	2			55

Tutorials – 55 hours
Total – 480 hours

Semester II

Course/ Paper	Name of the Course	Marks			Credit	Hours		
		Class Test	Final	Total		CT	L	Total
Theoretical								
SII-BOT-1/T	Plant Physiology and Metabolism	20	55	75	6	3	57	60
SII-BOT-2/T	Taxonomy of Angiosperms and Plant Developmental Biology	20	55	75	6	3	57	60
SII-BOT-3/T	Microbiology	20	55	75	6	3	57	60
SII-BOT-IDC2	Inter Disciplinary Course (IDC)-II*	30	70	100	8	5	75	80
Practical								
SII-BOT-4/P	Plant Physiology and Metabolism			25	2			55
SII-BOT-5/P	Taxonomy of Angiosperms and Plant Developmental Biology			25	2			55
SII-BOT-6/P	Microbiology			25	2			55

Tutorials – 55 hours
Total – 480 hours

Semester III

Course/ Paper	Name of the Course	Marks			Credit	Hours		
		Class Test	Final	Total		CT	L	Total
Theoretical								
SIII-BOT-1/T	Biology and Diversity of Algae, Bryophytes, Pteridophytes, Gymnosperms, Palaeobotany and Palynology	20	55	75	6	3	57	60
SIII-BOT-2/T	Ecology, Evolution and Plant resource utilization	20	55	75	6	3	57	60
SIII-BOT-3/T	Bioinformatics and Biostatistics	20	55	75	6	3	57	60
Practical								
SIII-BOT-4/P	Biology and Diversity of Algae, Bryophytes, Pteridophytes, Gymnosperms, Palaeobotany and Palynology.			25	2			55
SIII-BOT-5/P	Ecology, Evolution and Plant resource utilization			25	2			55
SIII-BOT-6/P	Bioinformatics and Biostatistics			25	2			55
Continuing Evaluation								
SIII-BOT-7/S	Seminar		50		4			40
SIII-BOT-8/G	Group Discussion		50		4			40

Tutorials – 55 hours

Total – 480 hours

Semester IV

Course/ Paper	Name of the Course	Marks			Credit	Hours		
		Class Test	Final	Total		CT	L	Total
Theoretical								
SIV-BOT-1/T	Plant Biotechnology and Genetic Engineering	20	55	75	6	3	57	60
SIV-BOT-2/ET	Special/Elective - Paper – I**	20	55	75	6	3	57	60
SIV-BOT-3/ET	Special/Elective - Paper – II**	20	55	75	6	3	57	60
Practical								
SIV-BOT-4/P	Plant Biotechnology and Genetic Engineering			25	2			55
SIV-BOT-5/EP	Corresponding to both the Special papers*			50	4			100
Continuing Evaluation								
SIV-BOT-6/DR	Project Work/Dissertation/Review		100		8			90

Tutorials – 55 hours

Total – 480 hours

*IDC-I and IDC-II mentioned here are to be pursued by students other than M. Sc. in Botany. Students of M. Sc. Botany will pursue IDCs in other PG Department(s) and it will be a 08+08=16 credit course spread over two semesters (Semester-I & II).

**Special/Elective Course (any one to be selected; each course contains two theory and one practical paper):

1. Cytogenetics,
2. Microbiology,
3. Mycology and Plant Pathology,
4. Plant Physiology, Biochemistry and Molecular Biology
5. Taxonomy of Angiosperms and Biosystematics

Semester-I (SI)

Paper SI-BOT-1/T - Biochemistry and Molecular Biology of plants (Theory)

1. **Carbohydrates:** Structure and function; Plant storage carbohydrates; Cell wall-structure & function; Glycoproteins & proteoglycans; sugar code.
2. **Lipids and membranes:** Structure and function; types and function of membrane lipids.
3. **Lipid metabolism:** Fatty acid biosynthesis and breakdown; Synthesis of storage and membrane lipids.
4. **Proteins:** Amino acid components and structural features; Primary, secondary, tertiary, quaternary and supra-molecular structures domains, motif and folds; Non-covalent interactions in relation to structural conformation; Ramachandran plots.
5. **Membrane Transport:** Membrane transport proteins; Primary and secondary active transport; Kinetic analysis of transport mechanisms; Membrane H⁺ and Na⁺-K⁺ ATPase. Importins and exportins.
6. **Amino acid biosynthesis:** α -Ketoglutarate and Oxaloacetate families.
7. **Nucleic acids:** Composition, three dimensional structures; helix (A, B, Z), different forms of RNA; DNA replication; Nucleic acid biosynthesis.
8. **Enzymology:** General catalytic properties; Enzyme kinetics- Michaelis- Menten and Lineweaver Burke plots; Negative and Positive co-operativity; Regulation of enzymes; Allosteric enzymes; Isozymes; Role of coenzymes and cofactors.
9. **Cell signaling:** Signaling molecules and their receptors, functions of cell surface receptors (G-protein coupled receptor, receptor PTK, cytokine and non-receptor PTK), second messengers. Cell interactions: Cellular adhesions, junctional proteins and receptors.
10. **DNA hybridization & sequencing:** Generation of radio-labeled probe and blotting techniques; Southern and Northern hybridization; DNA Sequencing methods; Polymerase chain reaction: Principles & methods.

Paper SI-BOT-2/T - Mycology and Plant Pathology (Theory)

MYCOLOGY

1. Introduction to Mycology: General principles of classification of fungi, Major Groups of Fungi; Fungal reproduction, Spore forms, Fungal Phylogeny and Evolution, fungal physiology, nutrition, and growth.
2. Ultrastructure of fungal cell and composition
3. Genetics and Cell cycle in yeast
4. Applied mycology: Overview; Fungi in fermentation technology; mycorrhiza in agriculture; Bioremediation;
5. Cultivation of edible mushroom: *Pleurotus* sp, and *Agaricus* sp
6. Lichens: Thallus structure, reproduction and economic importance.

PLANT PATHOLOGY

7. Principles of Plant Pathology.

8. Host pathogen interactions: Mechanism of penetration and the process of disease development.
9. Mode of infection and role of enzymes and toxins in plant disease.
10. Plant defense mechanism: Preexisting structural and induced structural and chemical defense
11. Structural and chemical decay of wood by wood decaying microorganisms
12. Major Fungal, Bacterial, Viral and Nematode diseases of Crop Plants.
13. Molecular methods for detection of plant pathogens
14. Methods of plant disease control
15. Epidemiology of plant diseases

Paper SI-BOT-3/T - Cytology and Genetics (Theory)

1. Chromosome structure and packaging of DNA; Euchromatin and heterochromatin; Karyotype analysis and evolution; specialized type of chromosomes; Molecular basis of chromosome pairing.
2. Cellular organelles: ultrastructure, function and their evolution.
3. Molecular mechanism of recombination; Plasmids, IS elements; Transposons and retro-elements; Sex-linked, sex-limited and sex-influenced traits; Sex determination; Sex differentiation; Dosage compensation and genetic imprinting; Maternal effects and cytoplasmic inheritance.
4. Mutation at morphological, biochemical and molecular level; modification and repair of DNA; Repetitive and unique DNA sequences.
5. Transcription in prokaryotes and eukaryotes; RNA processing; RNA editing; Regulation of gene expression; Operon circuits.
6. The genetic code and its evolution; Translation in prokaryotes and eukaryotes.
7. Population Genetics- populations, gene pool, gene frequency; Hardy-Weinberg Law; concepts and rate of change in gene frequency through natural selection, migration and random genetic drift; molecular clock and phylogenetic evolution.
8. DNA fingerprinting; RAPD, RFLP, AFLP; genetic, cytogenetics and physical mapping using molecular markers; Fluorescent in situ hybridization (FISH) and Genomic in situ hybridization (GISH) and their implications.
9. Genomics; The Human genome project and its importance; Functional and comparative genomics.
10. Principles of Plant breeding; conventional methods of breeding self and cross-pollinated plants; Polyploidy and Evolution of major crop plants wheat, cotton, rice; pre-breeding for crop improvement; green revolution and rice breeding.

Paper SI-BOT-4/P - Biochemistry and Molecular Biology of plants (Practical)

1. Preparation of buffers, solutions and dilutions.
2. Extraction of proteins from plant materials and estimation by Lowry's method using BSA standard curve.
3. Extraction of carbohydrates from plant materials and estimation of reducing sugars by Somogyi-Nelson method.
4. Determination of acid value of fat.

5. Extraction of plant phenolics and estimation of total phenols and O-dihydroxy phenols.
6. Separation of amino acid mixture by thin layer chromatography.
7. SDS-PAGE analysis of proteins
8. Isolation of plant genomic DNA, estimation by UV spectroscopy.
9. Isolation of plant total RNA, estimation by UV spectroscopy and gel electrophoresis.

Paper SI-BOT-5/P - Mycology and Plant Pathology (Practical)

1. Sterilization and incubation- principles and uses of instruments.
2. Culture media and their preparation.
3. Preparation of stabs, slants and pouring of plates.
4. Isolation of fungi from water/soil/air by culture plate technique.
5. Isolation of pathogen from diseased tissues.
6. Preparation of pure culture and sub culturing.
7. Inoculation of tuber and fruit.
8. Morphological and reproductive structure of some macro and micro fungi.
9. Symptomology and histopathology of some common diseases with diagnostic characteristics.
10. Isolation of fungal DNA and PCR based analysis.
11. Fungal tissue- culture; Preparation of spawn and cultivation of *Pleurotus*.
12. Identification of specimens from field trip.

Paper SI-BOT-6/P - Cytology and Genetics (Practical)

1. Orcein and Feulgen staining of metaphase plates; Preparation of karyotype and idiogram with analysis.
2. Linear differentiation of chromosomes through G-banding, C-banding and Q-banding
3. Induction of polyploidy using colchicine; different methods of application of colchicines
4. Study of Meiosis in *Allium*, *Tradescantia*, *Petunia*, and other plants.
5. Study of chromosomal aberrations with chemical mutagen treatments.

Semester-II (SII)

Paper SII-BOT-1/T - Plant Physiology and Metabolism (Theory)

1. **Transport and translocation of water and solutes** Properties and movement of water molecules; Water balance of the plant; Water transport through xylem; Mechanism of loading and unloading of photoassimilates and translocation in the phloem

2. **Sensory Photobiology:** Structure, function and mechanisms of action of phytochromes, cryptochromes and phototropins; Photophysiology of light induced responses; Stomatal movement; photoperiodism and biological clocks
3. **Plant growth regulators and elicitors:** Physiological effects, mechanism of action and signal transduction of auxins, gibberellins, cytokinins, ethylene and abscisic acid; Biological action of Brassinosteroids and peptide hormones.
4. **Physiology of plant development and flowering:** Embryogenesis - apical-basal & radial patterning; Developmental control of root and shoot apical meristem; leaf development and; Endogenous clock and its regulation; Concept of Florigen; Genetic and molecular analysis of floral induction and development.
5. **Stress Physiology:** Concept of tolerance and acclimation; Plant responses to biotic (pathogen and insects) and abiotic water deficit, salinity, metal toxicity, freezing and heat stress; Mechanism of oxidative stress and abiotic stress tolerance
6. **Secondary metabolites:** Characteristic features of secondary metabolites of plant origin; Basic metabolic pathways and origin of secondary metabolites; biosynthesis and biological significance of terpenes, phenolics and nitrogen-containing compounds.
7. **Photochemistry and photosynthesis:** General concepts; photosynthetic pigments and light harvesting complexes; photo-oxidation of water; mechanisms of electron and proton transport; Benson-Calvin cycle; CO₂ concentrating mechanisms
8. **Respiration:** Overview of plant respiration; Glycolysis; TCA cycle, Electron Transport systems and ATP synthesis; Photorespiration Alternative oxidase system.

Paper SII-BOT-2/T - Taxonomy of Angiosperms (Theory)

1. **Nomenclature** - different methods. Sources of Names
2. Concept of ICBN and ICN; brief knowledge of nomenclatural types as per Melbourne-ICN (2012); Major Rules: (a) Type concept; (b) Principle of priority; (c) Valid publication; (d) Starting points of Nomenclature, and (e) Limitations to the principle of priority
3. Evolution of characters and differentiation of species
4. **Taxonomic Data Sources:** (a) Anatomy, (b) Cytology, (c) Embryology, (d) Palynology, (e) Phytochemistry, (f) Genome Analysis, (g) Nucleic acid hybridization
5. **Taxonomic Tools:** Herbaria, Floras, Serological & Molecular Techniques
6. **Botanic Gardens** - importance, examples and acronyms. Processing of herbarium specimens
7. Taxonomic hierarchy
8. History of Plant Classification, Phenetic versus phylogenetic systems, cladistics; Current systems of Classifications; broad outline of APG-III (2009) including its merits and demerits.
9. Taxonomic literature and artificial keys
10. **Salient features, Floral range and phylogenetic importance of the following families:**
11. *Dicots*- Amborellaceae, Annonaceae, Papilionaceae, Caryophyllaceae, Apocynaceae, Lamiaceae, Droseraceae, Nepenthaceae, Rubiaceae, Ericaceae, Asteraceae, Dipsacaceae.
12. *Monocots*- Alismataceae, Potamogetonaceae, Zingiberaceae, Commelinaceae, Orchidaceae, Poaceae, Iridaceae, Juncaceae.
13. **Biodiversity** - importance and preservation; Conservation Hotspots, IUCN guide lines; invasions & introductions, endemism

14. **Numerical Taxonomy:** Aims and objectives, characters and attributes, OTUs. Coding cluster analyses, merits and demerits.
15. **DNA bar-coding** for identification of plants.

Paper SII-BOT-3/T - Microbiology (Theory)

1. **Diversity:** Phototrophic bacteria; Chemolithotrophic bacteria; Spirochetes; Rickettsias; Chlamydias; Mycoplasmas; Myxobacteria and Archaea.
2. **Taxonomy:** Classification and survey of microorganisms; Microbial phylogeny as revealed by rRNA sequencing Nomenclature; Species concept; Criteria for classification; Bergey's Manual
3. **Functional anatomy of cells:** Cell surfaces (glycocalyx, cell wall, flagella and pili) and their role; Plasma membrane (bacterial and archaeal) and transport across them; Survival through the production of spores and cysts
4. **Metabolism:** Photosynthesis (anoxygenic and oxygenic); Chemosynthesis; Fermentation (alcoholic, Entner-Doudoroff pathway; lactic acid – homo and hetero, propionic acid, mixed acid, butanediol and butanol; Stickland reaction); Respiration (anaerobic and aerobic), Nitrogen metabolism and Biological nitrogen fixation
5. **Growth:** Measurements of growth; Growth cycle of populations; Generation time; Continuous culture; Synchronized growth; Diauxy; Growth on solid media; Environmental factors influencing growth
6. **Genetics:** Storage and expression of genetic information (prokaryotic chromosome, plasmid and ribosome); Replication of prokaryotic chromosomes; Molecular basis of mutation; Isolation of mutants; Gene transfer mechanisms (transformation, transduction and conjugation); Regulatory mechanisms in bacteria- induction, repression, feedback inhibition, catabolite repression and attenuation; Vital operons
7. **Medical Microbiology:** Pathogenic properties of bacteria: toxins and extracellular enzymes; brief account of major human disease and their bacterial pathogens. Principles of chemotherapy, general account of chemotherapeutic agents, sulfa drugs and antibiotics.
8. **Fundamentals of Immunology:** History of immunology, innate and acquired immunity, humoral and cell mediated immunity, organ and cells involved in immunity, T cells and B cells; antigens: characteristics and types, adjuvants. Immunoglobins: types, structure and properties.
9. **Viruses and acellular microbes:** Nomenclature and classification, distinctive properties of virus, morphology and ultrastructure, capsid and their arrangements, types of envelopes and their composition, viral genome, their types and structure, virus related agents (viriods and prions). Viral replication: lytic and lysogenic.

Paper SII-BOT-4/P - Plant Physiology and Metabolism (Practical)

1. Determination of amylase activity of monocot seeds in different stages of germination.
2. Assay of catalase of seedlings growing in different environment.

3. Study of mobilization of starch during seed germination by amylases.
4. Determination of total acidity of cell sap.
5. Effect of kinetin on cotyledon enlargement.
6. Effect of different solutes and temperature on membrane permeability.
7. Effect of solutes on the response of membranes to different chemicals.
8. Preparation of standard curve and estimation of protein
9. Preparation of standard curve and estimation of amino acids
10. Determination of Hill activity by isolated chloroplasts
11. Extraction of chloroplast pigments and quantitative estimation.

Paper SII-BOT-5/P - Taxonomy of Angiosperms (Practical)

1. Workout of plant specimens and description of vegetative and reproductive characters from representative families locally available.
2. Training in using local floras and other literature and herbaria for identification of specimens described in the classes.
3. Study of various taxa of a genus, location of key characters and preparation of keys at species level.
4. Field excursion for familiarization with and study of vegetation type(s) and flora(s) of different areas in and outside the state, and in the local areas, and training in collection and preservation methodologies.

Paper SII-BOT-6/P - Microbiology (Practical)

1. Differential Staining (Gram and endospore) and study of morphology of prokaryotic cells.
2. Isolation of bacteria using streak-plate, pour-plate and spread-plate techniques.
3. Evaluation of disinfectants (phenol coefficient) as a measure of controlling microbial growth.
4. Isolation and enumeration of viable microorganisms from soil by serial dilution-agar plate method; isolation and study of rhizobia from root nodules.
5. Study of bacterial growth using turbidimetric method.
6. Measurement of wet weight and dry weight of bacterial cells during growth.
7. Determination of quality of milk using Breed's and methylene blue reduction methods.
8. Antibiotics sensitivity test using paper disc method.
9. Determination of the influence of temperature, pH, osmotic pressure and aeration on microbial growth.

Semester—III (SIII)

Paper SIII-BOT-1/T - Phycology, Bryology, Pteridology, Gymnology, Paleobotany and Palynology (Theory)

Phycology

1. Algae in diversified habitats: Terrestrial, fresh water and marine
2. Thallus organization,
3. Cell ultrastructure
4. Reproduction
5. Criteria for classification: Pigments, Reserve foods and flagella
6. Salient features of major groups: Cyanophyta, Prochlorophyta, Chlorophyta, Bacillariophyta, Phaeophyta and Rhodophyta.
7. Economic importance: Algal blooms, Algal biofertilizers, Algae as food, feed and uses in industry

Bryology

1. Salient features of major groups
2. Spore germination in liverworts and mosses
3. Alternative pathways in life cycles of bryophytes
4. Bryophytes as indicators of pollution
5. Useful chemical constituents
6. Fossil bryophytes as indicators of past environment and past plant communities

Pteridology

1. Basic adaptation on land
2. Salient features of major groups
3. Origin and evolution of pteridophyta
4. Stelar evolution in pteridophyta
5. Telome theory and origin of megaphyll
6. Eusporangiate and leptosporangiate ferns
7. Useful chemical constituents
8. Economic importance

Gymnology

1. Classification and salient features of major taxa
2. Origin and evolution of gymnosperms
3. Distribution through different era
4. Distribution in India: Fossil and living

Palaeobotany

1. Sedimentary rocks; Stratigraphy; Geological Time Scale; Basic concepts of continental drift and plate tectonics
2. Taphonomy
3. Coal, petroleum – origin and depositional environment coal and petroliferous basins of India
4. Reconstruction of fossil plants
5. Dating of fossils

6. Colonization of land; emergence of seed plants; appearance of angiosperms
7. Fundamentals of palaeogeography, palaeoecology and palaeoclimatology

Palynology

1. Branches of palynology
2. Spore, pre-pollen and pollen morphology,
3. Wall chemistry, exine ornamentation
4. Evolution of aperture types
5. Application of neopalynology and palaeopalynology

Paper SIII-BOT-2/T - Ecology, Evolution and Plant resource utilization (Theory)

Evolution:

1. Origin of cells and unicellular evolution- origin of basic biological molecules; concept of Oparin and Haldane; Miller's experiment (1953); evolution of prokaryotes; origin of eukaryotic cells and evolution of unicellular eukaryotes.
2. Theories of organic evolution: Lamarck; Darwin-concepts of variation, adaptation, struggle, fitness and natural selection; Mendelism; Spontaneity of mutations; the evolutionary synthesis.
3. Molecular evolution; Concepts of neutral evolution; Molecular divergence and molecular clocks; origin of new genes and proteins; gene duplication and divergence.
4. Adaptive radiation; isolating mechanisms; Speciation; Allopatricity and Sympatricity; Convergent evolution; Sexual selection; Co-evolution.

Ecology:

1. Concept and dynamics of ecosystem, components, food chain and energy flow, ecological pyramids; productivity and biogeochemical cycles; Different types of ecosystems (grassland and Savannas, shrubland and deserts, Tundra and taiga, Temperate forests, Tropical forests, Lakes and ponds, freshwater wetlands, Streams and rivers, Oceans, Estuarine and mangrove)
2. Population ecology (Basic characteristics with examples, life table, survivorship curves, growth curves) and biological control; Community structure and organization; Environmental pollution; Sustainable development
3. Ecosystem dynamics and management; Stability and complexity of ecosystems; Environmental Impact assessment, Principles of conservation; conservation strategies; cryopreservation, Sustainable development.

Plant resource utilization:

1. Traditional knowledge on the use of Bioresources: - Utilization, need, survey, evaluation and conservation. Non-Timber Forest Producers
2. Microbial Resources: - Biofertilizers, Biopesticides, Mycorrhizae, Edible Mushroom (*Agaricus*, *Pleurotus* and *Volvariella*) - cultivation and management
3. Plants and Civilization: Centres of origin and gene diversity; Botany, utilization, cultivation and improvement of food plants, drug, fibre and industrial values; Unexploited plants of potential economic value; Plants as a source of renewable energy; Genetic resources and their conservation, cryopreservation

Paper SIII-BOT-3/T - Bioinformatics and Biostatistics (Theory)

Bioinformatics:

1. Introduction to the concept of hardware and software.
2. Introduction to Windows, UNIX and Linux; Introduction to Perl and Python.
3. Different types of biological databases like sequence databases, structural, genomic and pathway interaction databases; information retrieval from biological databases; sequence analysis overview.
4. Introduction to genome browsers; Online bioinformatics tools; Different types of file formats used in bioinformatics analysis; Genome annotation.
5. Nucleotide and protein sequence analysis, sequence alignment and applications.
6. Phylogenetic analysis.
7. Introduction to protein structure prediction and analysis; drug designing.

Biostatistics:

1. Sampling and sample designs; Classification and tabulation of data; Visualizing data (diagrammatic and graphical presentation)
2. Measures of central tendency and dispersion
3. Probability distributions
4. Difference between parametric and non-parametric statistics
5. Confidence interval; Errors; Levels of significance
6. Regression and correlation; t-test; ANOVA; Chi-square test
7. Basic introduction to multivariate statistics
8. Application of SPSS, Sigmaplot, XLSTAT etc. in solving statistical problems

Paper SIII-BOT-4/P - Phycology, Bryology, Pteridology, Gymnology, Paleobotany and Palynology (Practical)

1. Morphological study of representative members of Cyanophyceae, Chlorophyceae, Phaeophyceae, Bacillariophyceae, Rhodophyceae
2. Study of reproductive members of different groups of Bryophytes
3. Study of reproductive structures of different groups of Pteridophyta.
4. Detection and bioassay of allelopathic substances of fern.
5. Comparative study of vegetative and reproductive structures of representatives of different groups of Gymnosperms
4. Study of important fossil Gymnosperms from prepared slides and specimens

Paper SIII-BOT-5/P - Ecology, Evolution and Plant resource utilization (Practical)

1. Estimation of dissolved oxygen content.
2. Estimation of dissolved carbonate & bicarbonate content.
3. Determination of soil pH.
4. Determination of soil quality: i) organic matter or ii) Exchangeable calcium and magnesium
5. Mushroom culture techniques

6. Nursery techniques of propagation
7. Study of economically important plants

Paper SIII-BOT-6/P - Bioinformatics and Biostatistics (Practical)

1. Nucleic acid and protein sequence retrieval
2. Sequence analysis techniques
3. Scripting and Perl/Python programming
4. Application of online tools and workflow design
5. Computer-oriented statistical techniques for solving descriptive and inferential statistical problems and performing different statistical techniques mentioned in the theoretical syllabus.

Semester—IV (SIV)

Paper SIV-BOT-1/T - Plant Biotechnology and Genetic Engineering (Theory)

1. Introduction and history of plant Tissue culture, culture media, Initiation and maintenance of Callus and suspension cultures; single cell clones
2. Biochemical production
3. Organogenesis; somatic embryogenesis; transfer and establishment of whole plants in soil
4. Rapid clonal propagation and production of virus -free plants
5. In vitro pollination; embryo culture and embryo rescue
6. Protoplast fusion, selection of hybrid cells; symmetric and asymmetric hybrids, cybrids.
7. Nuclear cytology of cultured plant cells and somaclonal variations
8. Production of haploid plants and their utilization
9. Cryopreservation and slow growth for germplasm conservation
10. Proteomics: Proteomics basic principles and applications. Protein-protein interaction *via* pull-down and yeast two-hybrid assay. DNA-protein interactions: DNase I footprinting.
11. Protein sequencing – principle and methods. MS/MS techniques for protein identification (PMF).
12. Basic principles of genetic engineering; Applications of recombinant DNA in agriculture and medicine; Restriction endonucleases, Modification methylases and other enzymes needed in genetic engineering.
13. Cloning vectors; Plasmids and plasmid vectors, Phages and Phage Vectors, phagemids, cosmids, artificial chromosome vectors (YAC, BAC), Animal virus derived vectors - SV40 and retroviral vectors; Cloning strategies & screening of recombinant clones.
14. Molecular cloning: Recombinant DNA techniques, construction of genomic DNA and cDNA libraries, screening of libraries
15. Expression strategies for heterologous genes
16. Use of transposons in genetic analysis: Transposon tagging and its use in identification and isolation of genes
17. Biosafety regulation: Physical and Biological containment

Paper SIV-BOT-1/T - Plant Biotechnology and Genetic Engineering (Practical)

1. Meristem tip culture
2. Somatic embryogenesis
3. Separation of amino acid mixture by thin layer chromatography.
4. SDS-PAGE analysis of proteins
5. Isolation of plant genomic DNA, estimation by UV spectroscopy
6. RAPD amplification and data analysis of a typical plant and dendrogram preparation and genetic distance measurement.
7. Isolation of plant total RNA, estimation by UV spectroscopy and gel electrophoresis.

Elective/Special Courses

(Anyone elective/special course to be opted for the 4th Semester; each course contains two theoretical and one practical paper)

Elective/Special Course: Cytogenetics

SIV-BOT-2/ET [Special paper – I (Theoretical)]

1. **Gene structure:** Genetic fine structure, *cis-trans* test, complementation test, overview of promoter structures and 5' capping, 3' polyadenylation in eukaryotic gene transcription, RNA transport, splicing-editing.
2. **Genome organization and Analysis:** An overview with nucleosome packaging, DNA structure, 'A', 'B' & 'Z' forms, Chromosome sorting by FACS, PFGE and microdissection.
3. **NGS:** High-throughput DNA sequencing (Illumina/Solexa technique), genome probing using DNA microarray (DNA chip), DNA databases and accessing genetic information *via* Bioinformatics algorithms.
4. **Recombinant DNA Technology:** Gene cloning principles; Tools-techniques, construction of genomic and cDNA libraries and screening-expression, choice of vectors and their structural features, *In vitro* mutagenesis and application. Antisense, ribozyme and RNAi technology and importance.
5. **Genome function:** Characterization of gene transcripts-transcriptomics *via* SAGE, Differential display, RNase protection assay, Northern blotting, nuclear run-on assay and genetic information passed on to protein-proteomics, and protein-protein interaction *via* pull-down and yeast two-hybrid assay, FRET; DNA-protein interactions: EMSA, DNase I footprinting, ChIP
6. **Transgenic crops:** Strategies to develop transgenic crops through *Agrobacterium* mediated or physical mediated gene transfer methods. Control and silencing of transgene expression.
7. **GM crops and ecological concern:** GM crops for disease/drought /insect/ herbicide tolerance and terminator technology. Advantages of Transplastomics and its development. Gene targeting through gene-knock-out using Cre-LoxP system and gene tagging in plants. Ecological risk and ethical issues of GM crops

SIV-BOT-3/ET [Special paper – II (Theoretical)]

1. **Genetic Markers and PCR amplification:** RFLP, RAPD, SNPs, FISH & Chromosome painting, Gene amplification and PCR: Basic principles and methodologies of PCR, design of PCR primers, RT-PCR and Real-Time PCR and their utility.
2. **Genome mapping:** Genetic mapping, physical mapping, sequencing genomes- assembly of a continuous DNA sequence, understanding of genome sequence- ORF, homology search and comparative genomics, exon-intron boundaries.
3. **Molecular plant breeding:** Theory and practices, molecular breeding tools- markers and maps; molecular techniques in Omics- functional and comparative genomics; breeding populations – DH, RIL, NIL, CSSL; marker assisted selection (MAS)- theory and practice; breeding informatics-plant Databases, prospects of breeding informatics, rice genome analysis- SNPs and InDels variations, analyses based on different genome browser-NCBI, Gramene, RAP-DB.
4. **Molecular dissection of complex traits-** QTLs, QTLs mapping across species (Rice); Rice biology in the genomic era; Development of improved rice varieties through molecular breeding - submergence tolerance, blight - blast resistant rice, salt tolerance rice- through gene introgression from donor parents and gene pyramiding.
5. **Genomes of prokaryotes and eukaryotic organelles:** Chromosomes of prokaryotes, genetic features of prokaryotic genomes; physical features of organelle genome and genetic content of organelle genomes.
6. **Molecular phylogenetics:** The origins of genome; RNA genome and DNA genome, acquisition of new genes, noncoding DNA and genome evolution; reconstruction of DNA-based phylogenetic trees and applications of molecular phylogenetics.
7. **Gene manipulation and applications:** Producing useful therapeutic molecules, pharmacogenomics, new drugs, improving agronomic traits by genetic modification. Metabolomics and global biochemical networks; analysis of transcriptomics and proteomics; gene inhibition at the protein level.

SIV-BOT-5/EP [Special paper – Practical]

1. Plant DNA isolation and its quantification by UV Spectrophotometer and Preparation of "Cot-curve" from isolated DNA
2. Restriction enzyme digestion of genomic DNA and its separation on 1% agarose gel electrophoresis and visualization on UV - transillumination after staining by Ethidium bromide
3. rDNA construction: Isolation of plasmid DNA and cut with restriction enzyme and ligation into known Vector pBR322/pUC series/pGEM-T.
4. Transformation of *E. coli* host using constructed chimeric plasmid
5. PCR and multiple arbitrary amplicon profiling (AP-PCR/RAPD) and data analysis with genetic distance measurement and dendrogram construction for phylogenetic study.
6. RT-PCR using reverse transcriptase and cellular mRNA as substrate.
7. Callus initiation and plantlets regeneration from tissue explants.

8. Rice genome analysis based on genome sequencing data of IRGSP-2005 or MSU7.
9. SSR marker profiling using rice genomic DNA and their analysis.
10. SNPs and InDels variation analysis based on whole genome sequencing data of rice, codon bias analysis and GC% analysis.

Elective/Special Course: Microbiology

SIV-BOT-2/ET [Special paper – I (Theoretical)]

1. **Microbial Systematics:** Classical and modern approaches to bacterial taxonomy, chemo-taxonomic characteristics (peptidoglycan, lipids, fatty acids and proteins) and genotypic characteristics (DNA-base composition, -fingerprinting, -relatedness; RNA sequence analysis, DNA-RNA hybridization); bacterial phylogeny.
2. **Genetics:** Genetic code- its nature and deciphering; Transcription; Translation; Plasmid biology (Types; Detection and purification; Replication); Transposons– Insertion sequences and composite transposons, phages as transposons, replicative, non-replicative and conservative transposition. Transformation; Conjugation; transduction; Bacterial genome mapping; Mutation and detection.
3. **Environmental microbiology:** Biofilms; Microbial competition and cooperation; Biogeochemical cycles (nitrogen, sulfur, phosphorus and iron); Microbial leaching of ores; Wastewater treatments; Biodegradation of petroleum and xenobiotics; Bacterial plastics; Metagenomics; Brief idea of exobiology; Methods in microbial ecology.
4. **Food Microbiology:** Food produced by microbes: Fermented foods (fermented dairy products, alcoholic beverages, vinegar, fermented vegetables), microbial cells as food. Food as substrate for microorganism, food borne disease; contamination and spoilage of food (meat and meat products, fish, fruits and vegetables, milk and milk products), methods of food preservation (physical and chemical); Probiotics
5. **Microbes in Agriculture:** Biological nitrogen fixation, nitrogenase and alternative nitrogenase system, *nif* genes; degradation of cellulose, hemicellulose and lignin, production of biofertilizers. Microbial control of insects. Use of viruses in agriculture.
6. **Bioinformatics & Computational Biology:** Advanced biological sequence analysis; Predictive methods using nucleotide and protein sequences; Advanced BLAST techniques; Codon usage analysis; Advanced molecular phylogenetics; Molecular modelling; Concepts of Next Generation Sequencing and NGS data analysis.

SIV-BOT-3/ET [Special paper – II (Theoretical)]

1. **Medical Microbiology:** Normal microbiota of human body; host-parasite relationship in bacterial pathogenicity: non-specific mechanisms of host defense, mechanism of bacterial virulence, genetics of bacterial virulence; chemotherapy: antibiotics (origin, classification, chemistry and mode of action); semisynthetic antibiotics; antibiotic resistance in bacteria, mechanism(s) of antibiotic resistance.

2. **Immunology:** Theories of antibody production, antibody diversity; antigen-antibody reactions; immunoassay methods and their applications, major histocompatibility complex (structure and function), complement system and complement activation; monoclonal antibodies (production and applications); Immunological techniques like immunoelectrophoresis and ELISA.
3. **Water microbiology:** Waterborne diseases; Microbial contamination of water; Examination of potability of water; Purification of water.
4. **Biotechnology and Industrial microbiology:** Major products of industrial microbiology; Biofuel production; Microorganisms used in industrial microbiology and their genetic manipulation.
5. **Virology:** Mechanism of virus adsorption and entry into the host cell including genome replication and mRNA production, mechanism of RNA synthesis, mechanism of DNA synthesis, transcription mechanism and post transcriptional processing, translation of viral proteins, assembly, exit and maturation of progeny virions, multiplication of bacteriophages.
6. Host and virus factors involved in pathogenesis, patterns of infection, pathogenesis of animal viruses, pathogenesis of plant and insect viruses. Host cell transformation by viruses and oncogenesis of DNA and RNA viruses; Characteristics of interferons; Induction and regulation of interferon production; Mechanism of interferon action.

SIV-BOT-5/EP [Special paper – Practical]

1. Quantifying the thermal death (D-values) of microorganisms
2. Study of physiological and biochemical activities of bacteria (hydrolysis of starch, lipid, protein and urea; degradation of cellulose and pectin; catalase; β -galactosidase; nitrate reduction; Voges-Proskauer reaction; indole production; liquefaction of gelatin; citrate utilization; fermentation/oxidation of sugars)
3. Study of bacterial growth and determination of generation time
4. Assay of antibiotics using tube dilution, well diffusion and agar dilution methods
5. Detection of coliforms using membrane filter method to determine water purity
6. Enrichment and isolation of anoxygenic phototrophic, endospore-forming and diazotrophic bacteria
7. Induction of mutation, and selection of mutants using replica plating technique
8. Isolation of antibiotic-resistant mutants
9. DNA isolation from bacteria/environmental sample and its quantification.
10. Restriction enzyme digestion of DNA
11. Polymerase Chain Reaction and Gel Electrophoresis.
12. Transformation of *E. coli*
13. Quantitative estimation of proteins by Folin-Lowry / Biuret method.
14. Chromatographic techniques
15. Nucleic acid and protein sequence analysis

16. Basic techniques of molecular modeling

17. Basics of NGS data analysis.

Elective/Special Course: MYCOLOGY and PLANT PATHOLOGY

SIV-BOT-2/ET [Special paper – I (Theoretical)]

- 1. Fungal diversity in different ecosystems:** The structure and composition of fungal cell, effect of environment on fungal growth and behavior.
- 2. Fermentation technology:** Feedstock for fermentation process, fermentor design and operation, solid substrate fermentations.
- 3. Enzyme technology:** Fungal enzymes of commercial importance, production of fungal enzymes, free and immobilized cells and enzymes.
- 4. Fungal toxins:** Mycotoxicoses- fungi in dermatomycosis, aspergillosis and fungi allergenic to man and animal.
- 5. Fungi as food and beverage:** Alcoholic beverage, mushrooms and other macro fungi, edible biomass from yeast and moulds, single cell proteins (SCP).
- 6. Fungi in food processing:** Bread, soybean products, cheese and fermented milk, other fermented foods
- 7. Fungal metabolites:** Primary metabolites of economic importance, secondary metabolites in medicine and agriculture
- 8. Future of fungal biotechnology:** Production of mammalian proteins by fungi, other applications of gene cloning in fungi and their importance
- 9. Recombinant DNA technology:** Manipulation of industrially important fungi, edible mushroom and bio-control agents

SIV-BOT-3/ET [Special paper – II (Theoretical)]

- 1. Biology of Mycorrhizae:** Diversity of Mycorrhizae and its development, Ectophytic and endophytic mycorrhiza (VAM), mycorrhiza in plant growth promotion, mycorrhizal interactions with soil microorganisms, mycorrhiza in plant disease control.
- 2. Molecular tools and methods:** Detection of Mycorrhiza; plant pathogens in soil, water and plant tissues.
- 3. Plant defense mechanisms:** Plants defense against infection: Preexisting structural and induced structural and chemical defense, hypersensitive reaction, role of phytoalexins and other phenolic compounds,
- 4. Management of plant diseases:** Cultural, chemical, biological, biopesticides, breeding for resistant varieties, plant quarantine, integrated pest management.
- 5. Post-harvest pathology:** Fungal deterioration of food commodities, mycotoxins and health hazards, control measures.
- 6. Molecular plant pathology:** Molecular aspects of host pathogen interactions - Systemic Acquired Resistance (SAR) and Induced systemic resistance (ISR), defense enzymes. PR proteins, degradation of phytoalexins; application of molecular biology to plant disease control - transgenic approach for crop protection, engineering chemicals that elicit defense response to plants.
- 7. Plant Diseases:** Study of major plant diseases caused by fungi, bacteria, viruses, nematode and mycoplasma like organisms

SIV-BOT-5/EP [Special paper – Practical]

1. Isolation of fungal/plant DNA and its quantification by spectrophotometric method.
2. Separation of DNA by agarose gel electrophoresis.
3. Restriction endonuclease digestion of fungal / plant DNA.
4. DNA blot hybridization.
5. Isolation of fungal protoplast.
7. Polymerase chain reaction.
8. Extraction and bioassay of phytoalexin(s) from plant tissue induced by biotic and abiotic stresses.
9. Partial purification of antifungal compounds by TLC methods and UV spectrophotometric analysis.
10. Extraction and SDS-PAGE analysis of defense protein in artificially inoculated plants/induced by abiotic elicitor(s).
11. Separation of proteins/polyphenols by column chromatography.
12. Extraction and assay of defense enzyme(s).
13. Immunological characterization of defense enzyme(s).
14. Preparation and purification of plant and fungal antigens.
15. Production of polyclonal antibody and purification of IgG.
16. Evaluation of antigens in raising antibodies using immunodiffusion and immunoelectrophoretic test.
17. Optimization of antigen and antisera dilution by ELISA.
18. Detection of pathogen in artificially inoculated plant using DAC-ELISA formats.
19. Detection of pathogen in soil by dot blot and western blot method.
20. Detection of pathogen in host tissue by indirect immunofluorescence test.

Elective/Special Course: Plant Physiology, Biochemistry and Molecular Biology

SIV-BOT-2/ET [Special paper – I (Theoretical)]

1. **Nitrogen metabolism:** Nitrate assimilation in plants, structure, function and regulation of nitrate assimilation enzymes, nif genes, nod genes - structure, function and regulation.
2. **Stress physiology:** Physiology and molecular biology of abiotic stress, biotic stress, reactive oxygen species and their protection mechanisms, role of polyamines in stress physiology.
3. **Senescence and its regulation:** Programmed cell death (PCD): Types, developmental and Molecular Biology of PCD, fruit ripening.
4. **Pumps, carriers and channels:** Structure and function, energetics of active transport, isophore and ionophore; Vacuoles – origin, structure and function.
5. **Sulfate metabolism:** Sulfur chemistry and function; Uptake and transport; reductive sulfate assimilation pathway; synthesis and function of glutathione and its derivatives.
6. **Floral induction and development:** Hormonal control, molecular genetics of floral development and floral organ differentiation; Effect of low temperature on floral bud initiation (FBI) through silencing of FLC gene.

7. **Protein targeting:** Protein transport in cell organelles, common features of the transport mechanism, chaperon, chaperonin and protein folding, protein glycosylation and its significance.
8. **Cell signalling:** Signal molecules, signal perception and transduction in plants; MAP-kinase, Ca-calmodulin complex – role in plant signaling.
9. **Protein chemistry:** Protein purification, characterization, methods for the determination of amino acids sequences in proteins, protein folding pathways and Levinthal Paradox.
10. **Alkaloids and carotenoids:** Classification, occurrence and biological properties, biosynthesis, and biological significance.

SIV-BOT-3/ET [Special paper – II (Theoretical)]

1. **Antisense technology and regulatory RNAs:** RNAi antisense oligonucleotides, basic principles and mechanisms. Small interfering RNAs (siRNA), MicroRNA (miRNA); synthesis and function of miRNA molecules.
2. **Protein modification:** Site specific and PCR-based random mutagenesis, characterization of the mutants.
3. **Epigenomics:** DNA methylation, Histone modifications (methylation, acetylation) their role in epigenetic control of gene.
4. **Importance of weak chemical interactions:** Concept of free energy, weak bonds in biological systems, hydrophobic bonds stabilize macromolecules; weak bonds attach enzymes to substrate, protein-protein interactions, protein-DNA interactions; specific conformation of a protein depends on pattern of Hydrogen bonds.
5. **Transcriptional regulation:** In prokaryotes and eukaryotic systems, gene silencing by modifications of histones and DNAs.
6. **Gene regulation in development and evolution:** Strategies for establishing differential gene expression in developmental stages, Homeotic genes- an important class of developmental regulators, positive autoregulation delays gene expression.
7. **Biogenesis, traffic, and functions of cellular membrane system,** Protein synthesis and folding in the cytoplasm; translocation into the endoplasmic reticulum- the signal hypothesis; Golgi function in biosynthetic processing.
8. **Catalytic RNA:** Introduction, group I and group II introns, catalytic activity of RNase P, Viroids have catalytic activity, protein splicing is autocatalytic.
9. **Somatic recombination and hypermutation in the immune systems:** Introduction, clonal selection amplifies lymphocytes, allelic exclusion; class switching is effected by DNA recombination.

SIV-BOT-5/EP [Special paper – Practical]

1. Protein extraction, precipitation by salting out, desalting by dialysis/ Sephadex G 25 column
2. Fractionation of proteins by molecular exclusion chromatography on Sephadex G 100.
3. SDS-PAGE analysis of the proteins and determination of molecular weights.
4. Enzyme extraction/assay of activity and isozyme analysis by PAGE.

5. Isolation of chloroplast and determination of Hill activity.
6. Separation of pigments by TLC and their identification.
7. Extraction and estimation of carotenoid pigments.
8. Determination of pKa values of amino acids.
9. Immunological techniques- ELISA and Western Blotting.
10. Separation and detection of secondary metabolites through TLC.
11. Determination of antioxidant fingerprint on TLC.
12. Isolation, purification and identification of alkaloids by application of column chromatography.

Elective/Special Course: Taxonomy of Angiosperms and Biosystematics

SIV-BOT-2/ET [Special paper – I (Theoretical)]

1. History of studies in Taxonomic Botany in India
2. Survey of Taxonomic Literature: Dictionaries, Indices, Monographs, Manuals, Floras, Journals, and taxonomic websites
3. The Species Concept
4. International Code of Botanical Nomenclature: Principles, articles, recommendations and special provisions; application of code with problems; nomenclature of cultivated and hybrid plants; taxonomic hierarchy.
5. Biocode and Phylocode
6. Use of Herbaria; role of Botanic Gardens in the 21st Century.
7. Biosystematics: definition, importance and categories. Major areas of biosystematic studies:
 - A. *Palynology*: morphology, chemistry of exine, bearing on phylogeny, reconstruction of vegetation structure
 - B. *Embryology*: Diversity in structures of gametophytes, endosperm formation, developing embryo; ovule morphology
 - C. *Cytology, genetics and breeding*
 - D. *Phytochemistry* (including serology, pigments & secondary metabolites)
 - E. *Molecular Biology*: Definition, determination of relationship through Protein & Nucleic Acid studies; uses of electrophoresis, PCR & HPLC.
 - F. *Remote sensing & GIS*.
8. Analysis of data; commonly available software, construction of dendrograms

SIV-BOT-3/ET [Special paper – II (Theoretical)]

1. Philosophy of classification. Recent trends in classification.
2. Indian flora. Endemism- in Indian perspective
3. Migration, dispersal and discontinuous distribution of plants
4. Management of Herbarium: Methods of collection, identification and documentation

5. Biodiversity Conservation: IUCN categories, Effects of Rio de Janeiro world summit, Hotspots, India as a megadiversity country; Ramsar sites
6. Methods of *in situ* and *ex situ* conservation. Biodiversity protected areas in India
7. Concise accounts of the phylogeny and economic importance of the following taxa:
 - a. SUBCLASSES:
 - i) Magnoliidae, (ii) Dilleniidae, (iii) Caryophyllidae, (iv) Alismatidae, (v) Commelinidae.
 - b. ORDERS:
 - i) Nymphaeales, (ii) Fagales, (iii) Gentiales, (iv) Dipsacales, (v) Liliales/Zingiberales, (vi) Orchidales.
8. Traditional knowledge: Ethnobotanical resources in India; documentation and utilization of ethnic knowledge. Traditional methods of conservation; sacred groves

SIV-BOT-5/EP [Special paper – Practical]

1. Seasonal collection of local flora, processing, Herbarium management.
2. Phenology of some common weeds.
3. Seed, endosperm, embryo and seedling morphology.
4. Identification of plants by matching.
5. Working out of different angiospermic plants (fresh and dry), their identifications using literature and preparation of artificial keys.
6. Phytosociological studies; Biological Spectrum; Determination of Diversity Indices (Shannon-Wiener, Species Richness & β -diversity).
7. Use of GPS and demonstration on the use of at least one remote-sensing software
8. Familiarity with Taxonomic Literature (e.g. Index Kewensis, Wall-Cat., Icones, Bibliographies, Dictionaries, Keys, Floras, etc.).
9. Preparation of temporary and permanent pollen slides; description of common palynomorphs, preparation of identification keys.
10. Variation of characters - influence of ecological factors.
11. Ethnobotanical survey in a forest village/ village market.
12. Use of Electrophoresis, PCR, HPLC and other instruments useful in molecular taxonomy.
13. Basic techniques of micropropagation.
14. Identification of secondary metabolites and pigments.

Interdisciplinary Courses (IDC)

(for students pursuing PG courses other than M. Sc. in Botany)

Course: IDC-I

Environment, Biodiversity Conservation and sustainable development

- I. **Environment and Ecosystems:** Concept of an ecosystem, Structure and function of an ecosystem, Producers, consumers and decomposers, Energy flow in the ecosystem, Food chains, food webs and ecological pyramids, characteristic features, structure and function of the following ecosystem- Forest ecosystem, Grassland ecosystem, Desert ecosystem and Aquatic ecosystems,
- II. **Biogeochemical Cycles:** Importance, gaseous and sedimentary cycles, Carbon, Nitrogen, Phosphorus and Sulphur Cycles, Oxygen Cycles, Hydrological cycles.
- III. **Succession:** Concepts of succession, Types of Succession, plan succession, Climax and stability.
- IV. **Biomes:** Major biomes of India, Characteristics of terrestrial fresh water and marine ecosystems, Forests, grasslands, lake, river and marine ecosystems of India.
- V. **Population:** Basic concepts, population characteristics – density, natality, mortality, age-structure, population growth, Ecological niche and habitat, Positive and negative interactions of populations – competition, predation, parasitism, mutualism.
- VI. **Community:** Basic concepts, community structure, growth forms, life form, Analytical and synthetic characters of plant community, Methods of plant community analysis, Concept of keystone species and ecotone.
- VII. **Biodiversity and conservation:** Basic concepts, Levels of biodiversity, biodiversity loss, Conservation of biodiversity- In-situ and Ex-situ conservation of biodiversity, needs and its issues, Sacred groove, Hot-spots of biodiversity, Overexploitation and its common pattern, international trade, problems in controlling in international trade (enforcement illegal trade), sustainable development, Value of biodiversity-consumptive use, productive use, social, ethical, aesthetic and option values; India as a mega-diversity nation.
- VIII. **Environmental problems:** Pollution-basic concepts of pollution (air, land and water), Pollutants (chlorinated hydrocarbon, organophosphate, and heavy metals) and impact, Greenhouse effect, acid rain, ozone depletion, deforestation, desertification, salination, chemical and radiation hazards, pesticide pollution, eutrophication, biological magnification, Solid waste management.
- IX. **Environmental protection act:** Environmental laws, national movement, environmental policies, environmental ethics-holistic approach of environmental

protection and conservation, IUCN-role in environmental protection, environmental protection agency (EPA).

- X. **Phytoremediation:** oil spills, wastewater treatment, chemical degradation, heavy metal.
- XI. **Renewable and non-renewable resources: Forest resources-** Use and over-exploitation, deforestation, timber extraction, mining, dams and their effects on forest and tribal people; **Water resources-** Use and over-utilization of surface and ground water, floods, drought, conflicts over water, dams-benefits and problems; **Energy resources-** Growing energy needs, renewable and non renewable energy sources, use of alternate energy sources.
- XII. **Human Population and the Environment:** Population growth, variation among nations, Population explosion – Family Welfare Programme, Environment and human health, Human Rights, Value Education, HIV/AIDS, Women and Child Welfare, Role of Information Technology in Environment and human health, Case Studies.
- XIII. **Field work:**
 - a. Visit to a local area to document environmental assets river/ forest/grassland/hill/mountain
 - b. Visit to a local polluted site-Urban/Rural/Industrial/Agricultural
 - c. Study of common plants, macro fungi, insects, birds
 - d. Study of simple ecosystems-pond, river, hill slopes, etc.

Course: IDC-II Biotechnology

- I. **Carbohydrates:** Structural aspects – Introduction & Occurrence, Classification of Mono-, Di- and Polysaccharides, Reducing & Non-reducing Sugars, Constitution of Glucose & Fructose.
- II. **Lipids:** Structural aspects – General introduction, Classification & Structure of Simple & Compound lipids, Properties of Lipid aggregates (elementary idea), Biological membrane, Membrane protein – structural aspects, Lipoproteins (elementary idea).
- III. **Protein Structural aspects:** General introduction, Classification & General characteristics, Structure of Primary, Secondary, Tertiary & Quaternary proteins (elementary idea), Classification of Amino acids.
- IV. **Nucleic acid Structural aspects:** Components of DNA and RNA, Nucleosides & Nucleotides (introduction, structure & bonding), Double helical structure of DNA (Watson-Crick model), various forms of DNA.

- V. **Genes are DNA:** DNA as genetic material, DNA double helix, semiconservative replication, mutations and Genetic code.
- VI. **Mutation:** Occurrence, kinds of Mutation, spontaneous & induced Mutation, Mutagens, detection of Mutation, Lethal Mutations, Biochemical Mutations, Phenotypic effects of Mutation, Molecular basis of Mutation, Significance & Practical applications of Mutation.
- VII. **Basics of Cell Biology (structure & function):** Discovery of cell and Cell Theory; Comparison between plant and animal cells; Cell wall; Plasma membrane; Modification of plasma membrane and intracellular junctions; Cytoskeleton; Protoplasm; Mitochondria; Chloroplast; ER; Golgi complex; Lysosome, endosome and microbodies; Ribosome; Centriole; Nucleus; Chemical components of a cell; Catalysis and use of energy by cells.
- VIII. **Structure and function of Prokaryotic cell & its components:** The Slime and the cell wall of bacteria; Concept of Gram-negative and Gram-positive bacteria, Mesosomes, flagella, Pilus, fimbriae, ribosomes, carboxysomes, sulfur granules, glycogen, polyphosphate bodies, fat bodies, gas vesicles; endospores, exospores, cysts.
- IX. **Pathogenic Microorganisms:** List of common bacterial, fungal and viral diseases of human beings and plants [Name of the disease, causative pathogen, parts affected].
- X. **Basic concepts of Virology:** General characteristics of viruses, differences between bacteria and viruses. Physical and chemical Structures of different Viruses- helical (TMV) and complex (Bacteriophage)
- XI. **Applications of Plant Genetic Engineering:** crop improvement, herbicide resistance, insect resistance, virus resistance, plants as bioreactors.
- XII. **Genetic modification in Agriculture:** transgenic plants, genetically modified foods, application, future applications, ecological impact of transgenic plants.
- XIII. **Cloning and PCR amplification:** Clone, Overview of the procedure, The importance of DNA Cloning, Gene library, Hybridization, PCR- basic features and application, Principles of Cell-based DNA Cloning, Cloning System for amplifying different sized fragments.
- XIV. **Purification and Separation of nucleic acids:** Extraction and Purification of nucleic acids, Detection and Quantitation of Nucleic acids, Gel Electrophoresis,
- XV. **Cutting and Joining DNA:** Restriction Endonucleases, Ligation, Alkaline Phosphate, Double Digest, Modification of Restriction Fragments ends, Other Ways of joining DNA Molecules.
- XVI. **Vectors:** Plasmid vectors, Vectors based on the lambda Bacteriophage, Cosmids, M13 vectors, Expression vectors, Vectors for cloning and expression in Eukaryotic cells, YACs and BACs.
- XVII. **Nucleic Acid Hybridization:** Principle and application - Preparation of nucleic probes, Principle of Nucleic acid hybridization, Nucleic acid hybridization assays, Southern blotting technique.
- XVIII. **Computational Genomics and bioinformatics:** Internet basics, biological data analysis and application, sequence data bases, NCBI model, file format, Protein primary

sequence analysis, DNA sequence analysis, pair wise sequence alignment, FASTA algorithm, BLAST, multiple sequence alignment, DATA base searching using BLAST and FASTA, Small molecules data bases, protein information, resources, protein data bank.

- XIX. **Genetic modification in Medicine:** Gene therapy, types of gene therapy, vectors in gene therapy, molecular engineering, human genetic engineering, problems & ethics.
- XX. **Genetic engineering in plants:** Use of *Agrobacterium tumefaciens*, Ti plasmids, Strategies for gene transfer to plant cells, Direct DNA transfer to plants, Gene targeting in plants, Use of plant viruses as episomal expression vectors.
- XXI. **Human Genome Project (HGP):** an overview of the project, goals of the project, major scientific strategies & approaches used in HGP, expected scientific & medical benefits of this project, about the organizations behind this project.

Suggested Readings

Bio-resource utilization

1. Advances in Mushroom Biotechnology- M.C. Nair, Ed.
2. A text book of Biotechnology-R.C. Dubey (S. Chand & Co.)
3. Food and Natural Resources- D.Pimentel and C.W.Hall, Academic Press
4. Plant Genetic Resources Conservation and Management- R.S.Paroda and R.K.Arora, IPGRI
5. Sustainable Management of Non-Wood Forest Products- M.N.B.Nair
6. The Useful Plants of India- CSIR, Publication and Information Directorate

Biostatistics

1. Fundamentals of Biometry – L.N.Balaam
2. Fundamentals of Biostatistics – I.A>Khan and A.Khanum,Ukaaz Publications
3. Principles of Biometry- C.M.Woolf
4. Statistical Methods – G.W.Snedecor and W.G.Cochran

Bryology

1. Bryophyta - N.S.Parihar , Central Book Depot, Allahabad
2. Bryophye Ecology – A.J.E.Smith (Ed)
3. Bryophytes – P.Puri, Atma Ram & Sons Publishers, N.Delhi
4. Cryptogamic Botany, Vol.II – G.M.Smith
5. Liverworts of the Western Himalayas and Punjab Plain – S.R.Kashyap

Cytology and Genetics

1. Genetics: PJ Russell. Benjamin Cummings Pub. Inc. USA.
2. Principles of Genetics: Snustad and Simmons, John Wiley and Sons, USA
3. Concepts of Genetics: Klug and Cummings, Pearson Education, USA
4. Genome 3: T.A. Brown, Pearson Education, USA
5. Principles of Gene Manipulation and Genomics: Primrose and Twyman, Blackwell Scientific, Oxford.
6. Plant chromosome: Analysis; Manipulation and Engineering: Sharma & Sharma, Harwort Academic Pub. Australia
7. The Science of Genetics: Sauders College Publishing, Fort Worth, USA
8. Genetics: Principles and Analysis, Hartl and Jones, EW Jones & Bartlett Pub, USA.
9. Gene IX: Lewin, B. Oxford University Press, USA.
10. Essential Genes, Lewin, B. Pearson Education.
11. Functional Genomics: A practical Approach. Hunt And Rick, Oxford University Press.
12. Genetic Engineering: An Introduction to Gene Analysis and Exploitation in Eukaryotes: Kingsman &Kingsman, Blackwell Scientific .Pub. Oxford.
13. Molecular Biotechnology: Glick & Pasternock, Indian Edition.

14. Molecular Cloning: A Laboratory Manual, Sambrook & Russel, CSHL press, N.York.
15. DNA Cloning: A Practical Approach, Glover & Hames, IRL press, Oxford.
16. Methods in Enzymology, Guide to molecular Technique, Vol. 152. Berger & Kimmel, Academic Press, San Diego.
17. DNA Science: A first course in recombinant Technology, Mickloss & Freger, CSHL Press, NY.
18. Recombinant DNA Technology: Watson, Academic Press.

Ecology

1. Basic Ecology –E.P. Odum , Saunders Publication
2. Fundamentals of Ecology-E.P. Odum , Saunders Publication
3. Elements of Ecology – R.L. Smith & T.M. Smith , Benjamin/ Cummings Publishers
4. Air pollution and Plant Life –M.T. reshaw , Willy Interscience
5. Concepts of ecology- E.J. Kormondy, Prentice-Hall of India
6. Fundamentals of Ecology- M.C. Dash , Tata McGraw Hill
7. Environmental Science-S.C. Santra , New Central Book agency(P) Ltd. Kolkata.
8. Biology of Fresh water pollution-C.F. Mason , Longman Publishers

Gymnology

1. An Introduction to Gymnosperms – S.C. Dutta
2. Comparative Morphology of Vascular Plants – A.S. Foster and G.M. Gifford
3. The Morphology of Vascular Plants – D.W. Bierhorst

Microbiology

1. Bacterial Metabolism - G. Gottschalk, Springer
2. Bergey's Manual of Systematic Bacteriology, 4 vols, - N.R. Krieg & J.G. Holt, eds, Springer
3. Brock Biology of Microorganisms - M.T. Madigan, J.M. Martinko & J. Parker, Prentice-Hall
4. Encyclopedia of Microbiology, 4 vols - J. Lederberg, ed, Academic Press
5. Food Microbiology - M.R. Adams & M.O. Moss, RSC
6. Food Microbiology- Fundamentals and Frontiers, 3rd edition, M.P. Doyle & L.R. Beuchat, ASM Press
7. Foundations in Microbiology - K.P. Talaro & A. Talaro, WCB/McGraw-Hill
8. Fundamentals of Microbiology - Alcamo, Benjamin/Cummings
9. Fundamentals of Microbiology and Immunology - A.K. Banerjee & N. Banerjee, Central
10. General Microbiology - H.G. Schlegel, Cambridge University Press
11. General Microbiology - R.Y. Stanier, E.A. Adelberg & J.L. Ingraham, McMillan
12. Genes VIII - B. Lewin, Oxford University Press
13. Immunology - J. Kuby, Freeman
14. Introduction to Modern Virology - N.J. Dimmock & S.B. Primrose, Blackwell Science
15. Microbial Energetics - E. A. Dawes, Blackie

16. Microbial Physiology - A.G. Moat & J.W. Foster, John Wiley & Sons
17. Microbiology - B.D. Davis et al., Harper & Row
18. Microbiology - L.M. Prescott, J.P. Harley & D.A. Klein, McGraw-Hill
19. Microbiology - M.J. Pelczar, E.C.S. Chan & N.R. Krieg, McGraw-Hill
20. Microbiology – An Introduction - G.J. Tortora, B.R. Funke & C.L. Case, Addison Wesley, Longman
21. Microorganisms in Our World - R.M. Atlas, Mosby

Molecular Plant Pathology and Fungal Biotechnology

1. Molecular Plant Pathology - M. Dicinson. Bios Scientific Publishers, Taylor and Francis group , London and New York
2. Fungal genetics: Principles and practice - Cees J. Bos , ed. Marcel Dekker, Inc.
3. The Mycota: Vol. I -XII : Ed. K. Esser :Springer Verlag, Berlin
4. Gene VI-Gene IX: Benjamin Lewin, Oxford University press.
5. Molecular and cellular biology of filamentous fungi-Nick Talbot , Oxford University Press.
6. Plant Pathology- 4th Edn. -G. N. Agrios, Elsevier Publications.
7. An Introduction to mycology - R. S. Mehrotra and K. R. Aneja., New age International publishers, New Delhi.
8. Topics in Mycology and Plant Pathology - L.N. Nair, New Central Book agency(P) Ltd. Kolkata.
9. Plant Pathology -concepts and laboratory Exercises - Robert N. Trigiano, Mark T. Windham and Alan S. Windham eds., CRC Press.
10. A text book of Plant Pathology - A.V.S.S. Sambamurty
11. Plant Pathology - Mehrotra and Agarwal, Tata McGraw Hill
12. Applications of PCR in Mycology – P.D. Bridge, D. K. Arora, C. A. Reddy and R. P. Elander Eds. , CAB International.
13. Molecular Plant Pathology: A practical approach, Vol. I & II- S.J. Gurr, M. J. McPhersson and D. J. Bowles, Eds., Oxford University Press.
14. Introduction to plant viruses- C.L. Mandahar , S. Chand & Co.
15. A text book of Biotechnology-R.C. Dubey , S. Chand & Co.

Paleobotany

1. An Introduction to Paleobotany – C.A.Arnold
2. An Introduction to the study of fossil plants – J.Walton
3. Paleobotany and evolution of plants- W.N.Stewart and G.W.Rathwell, Cambridge University Press
4. Studies in Paleobotany – H.N.Andrews

Phycology

1. Algae and Water Pollution – C.M. Palmer
2. An Introduction to Algae – I. Morris, Cambridge University Press
3. Phycology – R.e.Lee
4. Structure and Reproduction of Algae – F.E. Fritsch
5. The Algae – V.J. Chapman and D.J. Chapman
6. The Ecology of Algae – F.E. Round, Cambridge University Press

Plant Biochemistry

1. Biochemistry- A.L. Lehninger, D.L. Nelson and M.M. Cox, CBS Publishers & Distributors, New Delhi
2. Biochemistry- J.M. Berg, J.L. Tymoczko and L. Stryer, Freeman Publishers
3. Biochemistry- L. Stryer, Freeman Publishers
4. Biochemistry- F.B. Armstrong, Oxford University Press
5. Biochemistry- J.H. Weil, New Age International Publishers
6. Biochemistry- G. Zubay, W.C. Brown Publishers
7. Biochemistry- D.Das, Academic Publishers
8. Biochemistry & Molecular Biology of Plants- B.B. Buchanan, W. Gruissen and R.L. Jones, I.K. International Publishers
9. Introduction to Plant Biochemistry - Goodwin and Mercer, CBS Publishers & Distributors.
10. Outlines of Biochemistry- E. Conn, P.K. Stumpf, G. Bruening and R.H. Doi, John Wiley & Sons
11. Outlines of Biochemistry- P.W. Kuchel and G.B. Ralston, Tata McGraw Hill Publishers
12. Photosynthesis- D.O. Hall and K.K. Rao, Cambridge University Press
13. Photosynthesis- D.W. Lawlor, Viva Books Pvt. Ltd.
14. Plant Biochemistry – Eds. P.M. Dey and J.B. Harborne, Hacourt Asia Pvt. Ltd and Academic Press
15. Plant Biochemistry & Molecular Biology- P.J. Lea and R.C. Leegood, John Wiley & Sons
16. Plant Metabolism-D. Richter, George Thieme Publishers
17. Plant Metabolism- D.t. Dennis, D.H. Tupin, D.D. Lefebure and D.B. Layzell eds., Longman Publishers
18. Principles of Biochemistry- H.R. Horton, L.A. Moran, R.S. Ochs, J.D. Rawn and K.G. Saimgeour, Prentice Hall Publishers, USA
19. Analytical Biochemistry- D.J. Holme and H. Peck, Longman Publishers
20. Basic Separation Techniques in Biochemistry- R.O. Okotore, New Age International
21. Biochemical Methods- S.Sadasivam and A.Manickam,, New Age International
22. Class Experiments in Plant Physiology- H. Meidner, George Allen & Unwin
23. Experimental Biochemistry: Theory and exercise in Fundamental methods- R.Switzer and L. Garritty, Freeman Publishers
24. Molecular Cloning: A Laboratory Manual- J.Sambrook, E.F.Fritsch, T.Maniatis, eds., Cold Spring Harbor Laboratory Press
25. Phytochemical Methods- J.B. Harborne, Chapman & Hall Publishers
26. Practical Biochemistry- K. Wilson and J. Walker, eds. Cambridge University Press

Plant Physiology and Pharmacognosy

1. Basic biophysics for Biologists – M. Daniel, Agro Botanica Publishers
2. Biochemistry and Physiology of Plant Hormones – T.C Moore, Springer-Verlag, New York, USA
3. Class experiments in Plant Physiology – H. Meidner, George Allen and Unwin

4. Concepts of Photobiology: Photosynthesis and Photomorphogenesis – G.S Singhal, G Renger, S.K Sopory, K.D Irrgang and Govindjee, Narosa Publishing House, New Delhi
5. Cultivation and Utilization of Medicinal Plants – C.K Atal and B.N Kanpur, Eds., Regional Research Laboratory, CSIR, Jammu Tawai
6. Encyclopaedia of Plant Physiology, Volume III: Secondary plant Products – E.A Bell and B.V Charlwood, Springer-Verlag
7. Experiments in Plant Physiology: A Laboratory Manual – D Bajracharya, Narosa Publishing House, New Delhi
8. Gel Electrophoresis of Proteins: A Practical Approach – B.D Hames, PAS, Oxford University Press, Oxford, U.K.
9. The Embryology of Angiosperms S.S Bhojwani and S.P Bhatnagar, Vikas Publishing House, New Introduction to Plant Physiology - E.G Hopkins, John Wiley & Sons, Inc., New York, USA
10. Medical Botany, Plants affecting Man's Health – W.H Lewis and M.P.F Elvin-Lewis, Wiley International Publication
11. Metabolism and Regulation of Secondary Plant Products – V.C Runneckles and E.F Conn.
12. Molecular Embryology of Flowering Plants – V Raghavan, Cambridge University Press, Cambridge
13. Patterns of Plant Development – T.A Steeves and I.M Sussex, Cambridge University Press, Cambridge).
14. Pharmacognosy – G.E Trease and W.C Evans, Bailliere Tindall Publishers
15. Pharmacognosy – S.B Gokhale and C.K Kokate, Pragati Prakashan
16. Pharmacognosy – V.E. Tyler, L. Brady and J.E Robbers, Varghese
17. Plant Anatomy – A Fahn, Pergamon Press, Oxford
18. Plant Growth and Development: A Molecular Approach - D.E Fosket, Academic Press, San Diego
19. Plant Physiology – F.B Salisbury and C.W Ross, Wadsworth Publishing Co., California, USA
20. Plant Physiology - L Taiz and E Zeiger, Sinauer Associates, Inc., Publishers, Massachusetts, USA
21. Polarity in Plants; Annual Plant reviews, Volume 12 – Keith Lindsey Ed. Blackwell publishing and CRC Press
22. Practical Biochemistry: Principles and techniques – K Wilson and J Walker, Cambridge University Press, Cambridge, UK
23. Practical Pharmacognosy – C.K Kokate, Vallabh Prakashan, Delhi)
24. Practical Pharmacognosy – P.K. Lala, Lina, MG Road, Kolkata
25. Phytochemical Methods: A Guide to Modern techniques of Plant analysis – T.C Harborne, Chapman and Hall, London
26. Research Experiences in Plant Physiology: A Laboratory Manual – T.C Moore, Springer-Verlag, New York, USA
27. Seeds: Physiology of Development and Germination - J.D Bewley and M Black. Plenum Press, New York
28. Stress Physiology – D.P. Singh, New Aga International (P) Limited, Publishers, New Delhi.
29. The Embryology of Angiosperms S.S Bhojwani and S.P Bhatnagar, Vikas Publishing House, New Delhi

30. Techniques and Practice of Chromatography – R.P.W Scott, Marcel Dekker, Inc., New York

Pteridology

1. Comparative Anatomy of Vegetative Organs of the Pteridophytes – Y. Ogura
2. Morphology of Vascular Plants (Lower Groups) – A.J.Eames
3. The Ferns – F.O. Bower
4. The Morphology of Pteridophytes – K.K. S Porne, B.I. Publishing
5. The Pteridophyte Flora of the Upper Gangetic Plain – N.P. Chowdhury

Taxonomy of Angiosperms

1. Flora of India (all vols.) - Botanical Survey of India
2. Taxonomy of Vascular Plants - G.H. Lawrence
3. The Identification of Flowering Plant Families - P.H. Davis & J. Cullen
4. Botanical Latin - W.T. Stearn
5. A Dictionary of Flowering Plants - J.C. Willis
6. An Integrated System System of Classification of Flowering Plants - A. Cronquist
7. The Evolution and Classification of Flowering Plants - A. Cronquist
8. The Families of Monocotyledons - R.M.T. Dahlgren, H.T. Clifford & P.F. Yeo
9. Flowering Plants of the World - V.H. Heywood
10. The Families of Flowering Plants (3rd Edn.) - J. Hutchinson
11. Plant Systematics - S.B. Jones & L.E. Luchsinger
12. A Handbook of Systematic Botany - S.C. Datta
13. Biodiversity – Principles and Conservation - U. Kumar & M.J. Asija
14. Advances in Ethnobotany - A.P. Das & A.K. Pandey
15. Plant Systematics - Gurucharan Singh
16. Text Book of Plant Taxonomy - V.N. Naik