University of Gour Banga

(Established under West Bengal Act XXVI of 2007)

N.H.-34(Near Rabindra Bhawan), P.O.:Mokdumpur Dist.: Malda, West Bengal, Pin-732103

M.Sc. in Botany

Two Years (Four Semesters) Syllabus

Main Feature of the Syllabus

M.Sc. in Botany

Semester	Paper No.	Paper Name	Nature	Exam Marks	Time	Internal assessment	Total Marks
I	I	Microbiology, Virology and Immunology	Theo.	40	2.00 Hr.	10	50
	II	Phycology, Bryology and Pteridology	Theo.	40	2.00 Hr.	10	50
	III	Mycology, Plant Pathology and Crop Protection	Theo.	40	2.00 Hr.	10	50
	IV	Microbiology, Virology and Immunology	Prac.	24	2.00 Hr.	6	30
	V	Phycology, Bryology and Pteridology	Prac.	24	2.00 Hr.	6	30
	VI	Mycology, Plant Pathology and Crop Protection	Prac.	24	2.00 Hr.	6	30
Total							**240**
II	VII	Cytology, Genetics, Biostatistics and Plant Breeding	Theo.	40	2.00 Hr.	10	50
	VIII	Plant Physiology and Biochemistry	Theo.	40	2.00 Hr.	10	50
	IX	Molecular Biology and Plant Biotechnology	Theo.	40	2.00 Hr.	10	50
	X	Cytology, Genetics, Biostatistics and Plant Breeding	Prac.	24	2.00 Hr.	6	30
	XI	Plant Physiology and Biochemistry	Prac.	24	2.00 Hr.	6	30
	XII	Molecular Biology and Plant Biotechnology	Prac.	24	2.00 Hr.	6	30
Total							**240**
III	XIII	Gymnosperm, Paleobotany, Palynology and Taxonomy of Angiosperm and Biosystematic	Theo.	40	2.00 Hr.	10	50
	XIV	Plant Ecology, Plant Biodiversity, Conservation Biology and Bio-resource utilization	Theo.	40	2.00 Hr.	10	50
	XV	Special Paper Part - I	Theo.	40	2.00 Hr.	10	50
	XVI	Gymnosperm, Paleobotany, Palynology and Taxonomy of Angiosperm	Prac.	24	2.00 Hr.	6	30
	XVII	Plant Ecology	Prac.	24	2.00 Hr.	6	30
	XVIII	Special Paper Part – I (Cytology and Molecular Genetics / Microbiology and Microbial Biotechnology / Plant Physiology)	Prac.	24	2.00 Hr.	6	30
Total							**240**
IV	XIX	Methods in Biology, Bioinformatics and Developmental Biology	Theo.	40	2.00 Hr.	10	50
	XX	Plant Anatomy and Pharmacognosy	Theo.	40	2.00 Hr.	10	50
	XXI	Special Paper Part - II	Theo.	40	2.00 Hr.	10	50
	XXII	Plant Anatomy and Pharmacognosy	Prac.	24	2.00 Hr.	6	30
	XXIII	Special Paper Part – II (Cell Biology and Plant Biotechnology / Microbiology and Microbial Biotechnology / Plant Biochemistry and Molecular Biology)	Prac.	32	2.30 Hr.	8	40
	XXIV	Project Work / Review, and Seminar					40+20 =60
Total							**280**
Grand Total							**1000**

Special papers:

1. Advanced Phycology and Algal Biotechnology
2. **Cytology, Molecular Genetics, Cell Biology and Plant Biotechnology ***
3. **Microbiology and Microbial Biotechnology***
4. Mycology and Plant Pathology
5. **Plant Physiology, Biochemistry and Molecular Biology***
6. Taxonomy of Angiosperm and Biosystematics

(* Special Papers will be offered subject to availability of Faculty members in the Department with the respective subject expertise.)

Detailed Syllabus

SEMESTER – I

SEMESTER – I:: THEORY

PAPER – I (Microbiology, Virology and Immunology) **FM = 50** **LP = 50**

GROUP: A:: Microbiology **Part Marks = 25** **LP = 25**

1. Modern criteria of bacterial classification; Brief account of evolution of bacteria.
2. Bacterial motility- Mechanism and regulation; chemotaxis; quorum sensing
3. Microbial Diversity and Extremophilies: Principal modes of metabolic diversity: Phototrophic bacteria; Chemolithotrophic bacteria; and Extremophiles (thermophilic, halophilic, acidophilic and alkalophilic bacteria). Unculturable bacteria. Overview of Spirochetes; Rickettsias; Chlamydias; Mycoplasmas; and Myxobacteria.
4. Growth and Differentiation: Bacterial growth; kinetics, growth curve, factors affecting growth; Endospore: structure, cytology, physiology and genetic aspects.
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. Recombination in bacteria.
7. Medical Microbiology: Pathogenic properties of bacteria: toxins and extracellular enzymes; brief account of human diseases and therapy.

GROUP: B:: Virology and Immunology **Part Marks = 25** **LP = 25**

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.
3. Viral genome, their types and structure; virus movements and transmission; viral replication: lytic and lysogenic and their regulations. Bacteriophage base vectors for cDNA and genomic libraries. 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.

PAPER –II (Phycology, Bryology and Pteridology) FM = 50 LP = 50

Group A: Phycology **Part Marks = 25** **LP = 25**

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. Algal resource utilization: algal biofertilizer, bio-fuels and bio-molecules with commercial application
7. Algal phenomena and their ecological significance: Algal blooms, El Nino, red tides and bioluminescence.

Group B: Bryology and Pteridology

Bryology **Part Marks = 25** **LP = 25**

1. Broad outline of classification, traditional and modern systems with reference to liverworts, hornworts and mosses, and evolutionary trends among Bryophytes.
2. Bryophyte ecology: substrate colonized by bryophytes, growth forms and life forms.
3. Bryophyte as site indicators-responses of bryophyte to environmental pollution, initial colonization and succession.
4. Bryophyte chemistry and cytology and their taxonomic implications
5. Characteristics, affinities and systematic position of Sphaerocarpales, Takakiales, and Monocleales.
6. Brief idea on: fossil bryophytes, photoperiodism, apogamy and apospory, vegetative modes of reproduction, Peristome characters and their importance, Bryophyte conservation.

Pteridology

1. Introduction; Outline of systematic treatment of Pteridophytes (Sporne, 1965); distribution of extant groups in time and space.

2. Early land plants; vegetative and reproductive organography, evolutionary significance of the members of Zosterophyllopsida, Trimerophytopsida, Isoetales and Sphenophyllales.
3. Stomatal types and their development; evolution of stele.
4. Types of spore, induction of spore germination, gametophyte types, biochemical aspects of gametophyte differentiation; antheridogens- chemical nature and mode of action; determination of femaleness in free sporing heterosporous plants; phytochemistry of pteridophytes.
5. Diversity of ferns in an ecological perspective; insect, microorganism –pteridophyte interactions, endangered and endemic pteridophytes and their conservation.
6. Cytogenetics and reproductive biology of ferns: polyploidy, apospory, apogamy, apomixis and hybridization; genetic variability in fern population- genetic load.

PAPER – III (Mycology, Plant Pathology and Crop Protection) FM = 50 LP = 50

Group A: Mycology **Part Marks = 25** **LP = 25**

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 of citric acid, alcohol and antibiotics (Penicillin).
8. Biodegradation and mycoremediation.

Group B: Plant Pathology and Crop Protection

Plant Pathology **Part Marks = 25** **LP = 25**

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.

Crop Protection

1. Control of plant diseases: exclusion, eradication, protection and therapy; fungicides: inorganic and organic; protectants and systemic fungicides and their mode of action; cultural and biological control; Biopesticides; Virus induced gene silencing.
2. Biotechnological approaches for diseases resistance.
3. Principles of Plant Viral Disease Management.
4. Plant quarantine: rules and provisions.
5. Study of the following diseases with reference to occurrence, symptoms, disease cycle and control measures: Blast disease of Rice, Sheath blight of rice, Bacterial blight of rice, Early blight and mosaic disease of Potato, Wilt of Pigeon pea, White rust of Mustard, Anthracnose of Mango, Mango malformation, Red rot of sugarcane, Little leaf of Brinjal, Root knot of Tomato.

SEMESTER – I:: PRACTICAL

PAPER –IV: Microbiology, Virology and Immunology

1. Preparation of culture media (synthetic, semi synthetic and complex); methods of sterilization and aseptic methods.
2. Isolation of microorganisms from natural samples by dilution plating method and development of pure cultures by streak-plate and pour-plate methods.
3. Determination of morphological (simple and differential staining), physiological and biochemical characteristics of some selected isolated bacteria.
4. Turbidometric estimation of bacterial growth, construction of bacterial growth curve; influence of physical and chemical factors on bacterial growth.
5. Enrichment and isolation of free-living nitrogen fixing bacteria from soil and isolation of *Rhizobium* from root nodule.
6. Determination of antibiotic sensitivity of some bacteria by disc diffusion method.
7. Isolation of bacteriophage and determination of phage-titer.
8. Observation of antigen-antibody reaction by Ring test.

9. Determination of blood group of individuals.
10. Immuno-precipitation test of antigen with antisera by Ouchterlony immuno diffusion method.
11. Field record and herbarium sheets of virus infected plants must be submitted.
12. Visit to some industries of microbiological interest.

PAPER-V: Phycology, Bryology and Pteridology

Phycology

1. Identification of members of different groups (maximum 5 genera from each group) - Cyanobacteria, Bacillariophyta, Euglenophyta and Chlorophyta.
2. Phytoplankton sampling and identification.
3. Estimation of Phosphate, nitrate, DO and BOD from water samples.
4. General principles of culturing algae in laboratory and growth measurement.
5. Seaweed identification – *Enteromorpha, Ulva, Padina* and *Sargassum.*
6. Collection of algae from different localities and through local tours; their preservation and identification. Field record and algal specimen collection to be submitted (minimum 10 specimens).

Bryology

1. Studies of vegetative and reproductive structures of: (A) Liverworts: Thallose and Foliose members: at least 5 specimens; (B) Mosses: Nematodontous, Arthrodontous (Both haplolepidous and Diplolepidous) and Cleistocarpic – at least 5 specimens. (Identification upto the Generic level).
2. Field record and plant collection to be submitted (not more than 10 herbarium specimens).

Pteridology

1. Comparative morpho-anatomical studies of vegetative and reproductive organs of some members of available pteridophytes with identification upto generic level.
2. Study of diagnostic features of important taxa.
3. Field records, collection and preservation of common taxa (Maximum 10).

PAPER –VI: Mycology, Plant Pathology and Crop Protection

1. Sterilization and incubation- principles and uses of instruments.
2. Culture media and their (stabs, slants and pouring of plates) preparation.
3. Isolation of fungi from water, soil and air by culture plate technique.
4. Isolation of pathogen from diseased tissues (leaf, stem and fruit).

5. Preparation of pure culture and sub culturing.
6. Study of morphological and reproductive structures of available representative members of the Myxomycotina, Mastigomycotina, Zygomycotina, Ascomycotina, Basidiomycotina and Deuteromycotina.
7. Study of ectotropic and endotropic mycorrhiza.
8. Identification of different fruiting structures of macro fungi, permanent slides with different reproductive structures of micro fungi, spore forms of rust fungi, lichens.
9. Assay of fungicide by spore germination test.
10. Biological control by dual culture technique.
11. Symptomology and histopathology of some common diseases with diagnostic characteristics in economically important diseased plant specimens.
12. Laboratory records regularly checked, permanent slides prepared during practical classes, preserved and dried specimens collected during field works should be submitted at the term-end examination.

SEMESTER – II

SEMESTER – II:: THEORY

PAPER –VII (Cytology, Genetics, Biostatistics and Plant Breeding) **FM = 50** **LP = 50**

Group A: Cytology and Plant Breeding

Cytology **Part Marks = 25** **LP = 25**

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.

Plant Breeding

1. Concept of plant breeding; types of variety selection – mass selection, pure line selection, clonal selection, bulk and pedigree selection and hybridization.
2. Heterosis and Hybrid vigour.
3. Polyploidy and mutation breeding.
4. Molecular plant breeding: molecular markers as new efficient tools in breeding.
5. Molecular markers assisted breeding – elementary ideas.
6. Dissection of quantitative traits: Principles and methods of QTL mapping.

Group B: Genetics and Biostatistics

Genetics **Part Marks = 25** **LP = 25**

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.
3. Extranuclear inheritance: Basis and mechanism, role of organellar genes.
4. 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.
5. Sex linked inheritance: Sex chromosomes and sex determination in plants, sex linked inheritance.
6. Quantitative inheritance: Concept, genes and environment heritability, penetrance and expressivity.
7. 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.
8. Population genetics: population, gene frequency in population, genetic equilibrium, Random mating population, Hardy-Weinberg Principle, barriers to gene flow and mechanism of speciation.

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.

PAPER –VIII (Plant Physiology and Biochemistry) **FM = 50** **LP = 50**

Group A: Plant Physiology **Part Marks = 25** **LP = 25**

1. Plant water relationship: Concept of water potential and its components; water movement mechanism through plants.
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, CO_2 concentrating mechanisms in plants (C1, C4, and CAM), regulation of C_3, C_4 and CAM cycles.
4. Structure, biosynthesis, cellular and molecular mode of action of auxin, gibberellins, cytokinin, ethylene, abscisic acid; brief account of brassinosteroids and polyamines.
5. Senescence: Pattern of senescence, physiological control of senescence; programme cell death in plants.
6. Phytochrome: Properties, phytochrome induced response, phytochrome signalling pathways, blue light responses.
7. Stress physiology: Responses of plants to abiotic (water, temperature and salt) stresses; mechanisms of resistance and tolerance to abiotic stresses.

Group B: Biochemistry **Part Marks = 25** **LP = 25**

1. The structure of atom, molecules and chemical bonds, Van der Waal's, electrostatic, hydrogen bonding and hydrophobic interaction; reaction orders, pH, buffer, indicator.
2. Bioenergetics: an overview, Thermodynamic principles in biology; concept of free energy; Energy rich bonds.
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. Enzymes: Enzyme properties, enzyme classification and nomenclature, enzyme activity, enzyme kinetics, enzyme inhibition. General account of coenzymes, isoenzymes, allosteric enzymes, ribozymes and abzymes.
6. Lipid metabolism: biosynthesis and oxidation of fatty acids.
7. Secondary metabolites: Secondary metabolites and their ecophysiological functions. Overview of terpenoidal, alkaloidal, and phenolic metabolites and their biosynthesis.

PAPER –IX (Molecular Biology and Plant Biotechnology) **FM = 50** **LP = 50**

Group A: Molecular Biology **Part Marks = 25** **LP = 25**

1. Biology of DNA and RNA; DNA forms, central dogma, central dogma reverse; DNA replication and its mechanism.
2. RNA synthesis and processing: Mechanism of transcription, capping and polyadenylation; RNA processing, RNA editing, splicing, 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. Operon: concept, inducible and repressible, positive and negative control, *Lac* operon, *trp* operon, *gal*, and *bio*-operon.
7. Transposable elements: Ac/Ds transposable elements, IS elements, P-element; Transposon tagging; Cloning by transposon tagging.

Group B: Plant Biotechnology **Part Marks = 25** **LP = 25**

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.

SEMESTER –II:: PRACTICAL

PAPER –X: Cytology, Genetics, Biostatistics and Plant Breeding FM = 30

1. Mitotic and meiotic chromosome analysis and phases of division.
2. Study of mitotic and meiotic abnormalities.
3. Pollen mitosis - *Allium cepa.*
4. Study of sex chromatin in cell population.
5. Testing of central tendency (mean, median, mode, variance, standard deviation and standard error), testing of goodness of fit from the supplied samples.
6. Emasculation and bagging techniques.

PAPER-XI: Plant Physiology and Biochemistry FM = 30

1. Determination of water potential of plant sample by gravimetric method.
2. Titrimetric test of organic acids from plant samples.
3. Tetrazolium test of seed viability.
4. Determination of Q_{10} value for water absorption by seeds.
5. Separation of photosynthetic pigments by paper chromatography.
6. Effect of uncouplers and inhibitors on respiration.
7. Colorimetric estimation: sugar (Anthrone method), amino acids (Ninhydrin method) and proteins (Lowry method).
8. Phenol estimation from plant samples.
9. Assay of enzymes: Catalase and Amylase.

PAPER –XII: Molecular Biology and Plant Biotechnology FM = 30

1. Tissue culture medium preparation.
2. Surface sterilization technique and preparation of explants.
3. Initiation of aseptic culture from seed, and nodal explant.
4. Study of callus culture and organogenesis.
5. Gel electrophoresis of protein.
6. Estimation of DNA and RNA.
7. Agarose gel electrophoresis technique for DNA.

SEMESTER – III

SEMESTER – III:: THEORY

PAPER –XIII (Gymnosperm, Paleobotany, Palynology and Taxonomy of Angiosperm and Biosystematics)	**FM = 50**	**LP = 50**

Group A: Gymnosperm, Paleobotany, and Palynology **Part Marks = 25** **LP = 25**

Gymnosperms

1. Concept of progymnosperms and its evolutionary significance.
2. Current concepts on classification of Gymnosperms up to order level with brief characterization of orders.
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. Karyology and phytochemistry of important taxa, endangered and endemic taxa and their conservation.

Paleobotany

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.

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.

Group B: Taxonomy of Angiosperm and Biosystematics **Part Marks = 25** **LP = 25**

Taxonomy of Angiosperm

1. Introduction: Definitions of terms: taxonomy, classification, identification, nomenclature, aims and scope of taxonomy, history and phases of taxonomy.
2. Tools of Taxonomy: Functions of field, herbarium, botanic gardens, floras / literature.
3. Concepts of Taxonomical Hierarchy: Species/genus/family and other categories, species concept.
4. Nomenclature: ICBN: Principles and rules (including fossils and cultivated plants), changes, addition and alternation of latest code, names of taxa, nomenclature types, rank of taxa, priority of publication and limitations; effective and valid publication; author citation; changes and rejections of names. Principle and idea about biocodes and phyllocodes.
5. Major systems of angiosperm classification: Outline of classification of Cronquist (1988), Thorne (2007) and Takhtajan (1997) upto subclasses/ super orders. Broad outlines of Angiosperm Phylogeny Group (APG) II, 2009 with the line concept of Magnollids, monocots, Commelinids, eudicots, core eudicots, Rosids, Fabeids, Malvids, Asterids, Lamiids and Campanulids.
6. A general survey of the following orders of angiosperms (*sensu* Cronquist, 1988) with salient features, inter relationships, evolutionary trends and economic importance: Magnoliales, Caryophyllales, Nepenthales, Podostemales, Asterales, Orchidales, and Liliales.

Biosystematics

1. Biosystematics: Definition, steps, categories, methods, relationship with classical taxonomy.
2. Data sources of Taxonomy: Concepts of character, relevance of phytochemistry, ultra structure and molecular taxonomy.
3. Numerical taxonomy: Principles, methods, merits and demerits.
4. Phylogenetic taxonomy: nature of phylogeny; heterobathmy, polarity and morphocline; anagenesis and cladogenesis; plesomorphy, apomorphy, synapomorphy, simplesiomorphy; parallelism and convergence; monophyly, paraphyly, polyphyly; importance of homology, polarizing characters of homology, homoplasy and problems of homoplasy; polygram, dendrogram and cladogram.
5. Cladistics: Basic principles, adaptive radiation, microevolution: theory and concepts; Phylogenetic systematics; species and speciation; Macroevolution inferring phylogenies.

PAPER –XIV (Plant Ecology, Plant Biodiversity, Conservation Biology and Bio-resource utilization) **FM = 50** **LP = 50**

Group A: Plant Ecology **Part Marks = 25** **LP = 25**

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.
9. Applied ecology: Environmental pollution: air particulate pollution, gaseous pollution (SO_X, NO_X, CO, Hydrocarbons, Ozone, and PAN) and their control; water pollution: heavy metals (As, Pb, Fe, Ca, Hg, and Cu).

Group B: Plant Biodiversity and Conservation Biology and Bio-resource utilization **Part Marks = 25** **LP = 25**

Plant Biodiversity and 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. Objectives and activities of BSI and NBPGR for conservation of plants.

Bio-resource utilization

1. Origin of Agriculture; World centers of origin of cultivated plants.

2. Origin, chemical constituents and uses of (a) cereal crops [rice, wheat], (b) fibre crops [jute], (c) legumes/ pulses [chick pea], (d) vegetables [cauliflower] (e) beverages [coffee, tea] (f) sugar crops (sugarcane) (g) spices and condiments (cardamom) (h) fruits (mango).
3. Important timber yielding plants and non-wood forest products: Paper making plants, Gum yielding plants, Resin yielding plants, Tannin yielding plants, Dye yielding plants, Rubber yielding plants: botanical names, families and uses; poisonous plants and their effects as hallucinogenic, allergic, teratogenic effects and other toxicity.

PAPER –XV (Special Paper Part - I) Cytology and Molecular Genetics FM = 50 LP = 50

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.

PAPER –XV (Special Paper Part - I) Microbiology and Microbial Biotechnology FM = 50 LP = 50

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.

PAPER –XV (Special Paper Part - I) Plant Physiology FM = 50 LP = 50

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-chemical properties and mode of action; Cryptochrome and blue light responses.
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 regulators and elicitors: Brassinosteroids, polyamines, jasmonic acid and 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 molecular biology.
10. Plant responses to abiotic stresses: Stress signalling (SOS pathway), osmotic adjustment, stress induced genes and proteins, genetic engineering of stress tolerance.

SEMESTER –III:: PRACTICAL

PAPER –XVI: Plant Ecology **FM = 30**

1. Study of morphological and structural adaptations of locally available hydrophytes, mesophytes, halophytes and epiphytes and correlate to their particular habitats.
   - Hydrophyte: *Nymphaea, Hydrilla*.
   - Xerophyte: *Nerium, Casuarina.*
   - Mesophyte: *Tridax, Vernonia*.
   - Halophyte: *Avicennia, Rhizophora*.
   - Epiphyte: *Vanda*.
2. Quadrat Analysis: (i) Determination of minimum quadrat size by species-area curve.

   (ii) Determination of minimum number of quadrats to be laid down.
3. Study of some endangered plant species and their conservation.
4. Assessment of **soil characteristics**:
   (i) Determination of pH of soil samples.
   (ii) Estimation of organic carbon content of different soil samples by Walkey method.
   (iii) Determination of water holding capacity of different soil samples.
5. Assessment of **water characteristics**:
   (i) Estimation of dissolved oxygen (DO) content of water by Winkler method
   (ii) Estimation of chemical oxygen demand (COD) of polluted water sample.
   (iii) Determination of phosphate and nitrate in different water samples.
   (iv) Estimation of total hardness of water by EDTA method.
6. Field visits: (a) Two field excursions to the different ecosystems (1 from each): (i) terrestrial (forest/ grassland) and (ii) aquatic (freshwater/ estuarine) and observation of vegetational types under the guidance of teachers. Only field note books to be submitted. (b) Familiarity with local conservation areas by field visit to Sacred Grove/ Botanical Garden/ Reserve Forest. Only field note book to be submitted.

PAPER-XVII: Gymnosperm, Paleobotany, Palynology and Taxonomy of Angiosperm FM = 30

Gymnosperms

1. Study on some extant taxa with reference to general habit, external and internal morphology with special reference to their male and female reproductive structures, pollen grains.
2. Laboratory records regularly checked, specimens collected and duly identified should be submitted at the term-end examination.

Paleobotany

1. Types of fossils, and modes of preservation.
2. Systematic study of some fossil plants through ages- *Rhynia, Lepidodendron, Sphenophyllum, Calamites,* members of Lyginopteridales, Medullosales, Glossopteridales: *Vertebraria* root, Cycadales, Pentoxylales, Cordaitales, Coniferales.
3. Laboratory records regularly checked, and fossil specimens collected and duly identified should be submitted at the term-end examination.
4. One visit to Birbal Sahni Institute, Lucknow.

Palynology

1. Study of morphology of modern spores and pollen grains by acetolysis method.
2. Studies of different types of spores (Pteridophytes) and pollen grains (Gymnosperms and Angiosperms): their shape, aperture and sculpture.
3. Laboratory records regularly checked, and permanent slides prepared during practical classes should be submitted at the term-end examination.

Taxonomy of Angiosperms and Biosystematics

1. Workout of plant specimens and description of vegetative and reproductive characters from representative locally available families.
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 specific level.
4. Field excursion for familiarization with and study of vegetation types(s) and flora(s) of areas outside the state and training in collection and preservation methodologies.
5. Laboratory records regularly checked, permanent slides prepared during practical classes, preserved and dried specimens collected during field works should be submitted at the term-end examination.

PAPER-XVIII: Special Paper Part – I (Cytology and Molecular Genetics) FM = 30

1. Isolation, estimation, localization (*in situ*.), digestion (with the use of restriction endonuclease) and amplification of DNA.
2. Scanning of chromosome aberrations (Mitotic and meiotic).
3. Comparative study of karyotypes of selected plant materials (both from root tips and leaf tips).
4. Effect mutagenic agent on plant system to note chromosomal irregularities.
5. Chromosome banding technique.
6. Estimation of total protein content as well as specific amino acids.
7. Data analysis using biometrical methods.

PAPER-XVIII: Special Paper Part – I (Microbiology and Microbial Biotechnology) FM = 30

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. Assay of antibiotics using tube dilution, well diffusion and agar dilution methods
4. Blood group determination using slide agglutination method.
5. Native PAGE of bacterial proteins.
6. Extraction of bacterial DNA and visualization by agarose gel electrophoresis.
7. Restriction digestion of DNA and its analysis by Agarose gel electrophoresis.
8. Amplification of specific gene by PCR.

PAPER-XVIII: Special Paper Part – I (Plant Physiology) FM = 30

1. Isolation of chloroplast and estimation of Hill activity.
2. Chromatographic separation and identification of amino acids.
3. Chloride ion estimation in leaves of aquatic and terrestrial plants.
4. Stomatal physiology: Effect of potassium nitrate on stomatal opening.
5. Effect of auxin on water absorption by potato tubers
6. Effect of auxin on elongation of coleoptiles of wheat.
7. Determination of chlorophyll contents in leaves of different physiological stages.
8. Estimation of ascorbic acid and phenol contents in fruit samples of different ages.
9. Determination of soluble and insoluble carbohydrate contents in the cotyledons of germinating seeds.
10. Estimation of proline content in leaves under water stress.
11. Effect of polyamines, jasmonic acid and salicylic acid in abiotic stress tolerance.

SEMESTER – IV

SEMESTER – IV:: THEORY

PAPER –XIX (Methods in Biology, Bioinformatics and Developmental Biology) FM = 50 LP = 50

Group A: Methods in Biology, and Bioinformatics **PART MARKS = 25 LP = 25**

Methods in Biology

1. Laboratory discipline, safety and care, laboratory note book, experimental report, standard units of expression.
2. Molecular biology and recombinant DNA technology: 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.
3. Histochemical and immune-techniques: Antibody generation, western blot, immuno-precipitation, flow-cytometry.
4. 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.
5. Biophysical methods: Analysis of biomolecules using UV/visible spectrophotometry, fluorescence, circular dichroism, NMR and ESR spectroscopy, structure determination using X-ray diffraction.
6. Chromatographic Techniques: 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. Radioisotope techniques: Isotopes in plant science, units and measurement of radioactivity – Geiger-Muller, liquid scintillation counting; Autoradiography, molecular imaging of radioactive material, safety guidelines.

Bioinformatics

- Bioinformatics: Definition, importance, constituents, application in genomics.

Group B: Developmental Biology **PART MARKS = 25 LP = 25**

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. Male gametophyte: Microsporogenesis, role of tapetum; pollen development and gene expression; male sterility; sperm dimorphism and hybrid seed production.
7. Female gametophyte: Ovule development; megasporogenesis; organization of the embryo sac, structure of embryo sac cells.
8. Pollination, Pollen-pistil interaction and fertilization: Breeding systems; commercial considerations; structure of the pistil; pollen stigma interactions, sporophytic and gametophytic self-incompatibility (cytological, biochemical and molecular aspects); double fertilization (structural and molecular aspect); *in vitro* fertilization.
9. Seed development and dormancy- Embryo and endosperm development; cell lineages during late embryo development; Seed maturation and dormancy; polyembryony; apomixis; apospory.

PAPER –XX (Plant Anatomy and Pharmacognosy) **FM = 50** **LP = 50**

Group A: Plant Anatomy **PART MARKS = 25** **LP = 25**

1. Differentiation of primary and secondary plant bodies: Ontogeny, differentiation of sclerides, fibres and their control of differentiation; vascular cambium; factors influencing cambial activity.
2. Secretory structures: Internal secretory structures – laticiferous tissue system, secretory cavities and ducts; external secretory structures – hydathodes, nectaries, salt glands and colleters; economic importance of plant secretions.
3. Plant anatomy in systematics and evolution: Xylem evolution; wood anatomy, nodal anatomy, floral vasculature, mineral inclusion in systematics and evolution.
4. Ecological anatomy: Leaf and wood anatomy in ecological perspective; anatomical response to pollutants.
5. Applied plant anatomy: Application of anatomical studies in climatology, genetics and plant breeding, biomedical research and forensic science.

Group B: Pharmacognosy **PART MARKS = 25** **LP = 25**

1. Introduction, scope, classification and pharmacological action of plant drugs.
2. Pharmacopoeias: Definition and examples.
3. Classification of plant drugs: Morphological and chemical- brief idea about different drug plants producing Carbohydrates, alkaloids, Glycosides and other secondary metabolites.
4. Concise account of macro and micro morphological features, constituents, adulterants and uses of following plants: *Atropa belladona, Catharanthus* spp., *Cephalis epecacuenha, Cinchona* spp., *Datura stramonium, Digitalis purpurea, Holarrhena, Rauvolfia, Strychnos*.
5. Volatile oils: Composition, volatile oil yielding plants and their uses as drugs.
6. Resins: different types, uses.
7. Quality control of plant drugs.

PAPER –XXI (Special Paper - II) **FM = 50** **LP = 50**

PAPER –XXI (Special Paper - II): Cell Biology and Plant Biotechnology **FM = 50** **LP = 50**

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).

PAPER –XXI (Special Paper - II): Microbiology and Microbial Biotechnology FM = 50 LP = 50

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).

PAPER –XXI (Special Paper - II): Biochemistry and Molecular Biology FM = 50 LP = 50

1. Nitrogen metabolism: Nitrate and ammonia assimilation and their control; Nitrogenase – inhibition and metal protein interaction.

2. Amino acids biosynthesis; Proteins synthesis, assembly and degradation; Protein sorting and vesicular trafficking.

3. Pigments: General overview; chlorophyll biosynthesis; Metabolic engineering of carotenoid pathway and phenylpropanoid pathway.
4. Signalling in plants: Receptors and signalling mechanism in plants.
5. 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.
6. Purification, structure determination and sequencing of Proteins, Carbohydrates and Nucleic acids. Genomics and Proteomics.
7. Manipulating structural genes and its expression for pathway enzymes: transposon mediated mutation and functional analysis of genes; Site-directed mutagenesis and its implications on structure function relationship of protein conformation.
8. Applications of tools of Biochemistry and Molecular Biology in:
    i. Radioisotopes in aid of structure and pathway design.
    ii. Detecting and analyzing Protein-protein interactions.
    iii. Detecting and analyzing DNA-protein interactions.
    iv. Detecting and analyzing DNA-protein interactions

SEMESTER –IV:: PRACTICAL

PAPER –XXII: Plant Anatomy and Pharmacognosy FM = 30

Plant Anatomy

1. Cell types- trichomes, sclerides, tracheids, vessel members and sieve tube elements.
2. Secretary structures and cell inclusions- necteries, glandular hairs, oil glands, salt glands, resin canals, laticifers, cystolith and crystals.
3. Study of different types of stomata (monocots and dicots).
4. Computing palisade ratio.
5. Nodal anatomy- unilacunar, trilacunar, multilacunar.
6. Anatomy of lenticels.
7. Anatomy of sun and shade leaves, xeromorphic leaves, succulent leaves, halophyte leaves, hydromorphic leaves.

Pharmacognosy

1. Choice of solvent for extraction of alkaloids, phenols.
2. Chemical tests for the detection of alkaloids, phenols, anthraquinones, cardenolides, anthocyanins, betacyanins, carotenoids.
3. Extraction and chromatographic detection of some common plant drugs.

4. Study of unorganized drugs – starches, gums, resins etc.
5. Techniques of studying stomatal index, vein islet number.
6. Organoleptic and microscopic evaluation of following plant drugs: (i) *Datura /Adhatoda / Azadirachta* (Leaf drug), (ii) *Cinchona / Holarrhena / Alstonia* (Bark drug) (iii) *Zingiber / Cephaelis* (Rhizome & Root drug), (iv) *Syzygium* (Flower drug) (v) *Coriandrum / Trachyspermum / Foeniculum / Cuminum* (Fruit drug), (vi) *Strychnos* (Seed drug).
7. One field trip to become familiar with economically important plants and their respective uses. Report enlisting the names of plants studied in the field should be submitted for term end evaluation.

PAPER-XXIII: Special Paper (Part – II) FM = 40

Special Paper– II: Cell Biology and Plant Biotechnology

1. Extraction of DNA from different sources (prokaryotic and eukaryotic: genomic, plasmid and organellar).
2. Purification, evaluation and amplification of extracted DNA.
3. Extraction of RNA from different sources (prokaryotic and eukaryotic).
4. Micropropagation of orchids and woody plants.
5. Somatic embryogenesis.
6. Detection of somaclonal variation.

PAPER-XXIII: Special Paper (Part – II) FM = 40

Special Paper– II: Microbiology and Microbial Biotechnology

1. Bacteriological examination of water using multiple-tube method.
2. Detection of coliforms using membrane filter method to determine water purity.
3. Enrichment and isolation of anoxygenic prototrophic, endospore-forming and diazotrophic bacteria.
4. Induction of mutation, and selection of mutants using replica plating technique.
5. Isolation of antibiotic-resistant mutants.
6. Isolation and enumeration of coliphage from sewage.
7. Detection and enumeration of indicator and index organisms for food borne pathogenesis (total Enterobacteriaceae, total coliforms, faecal coliforms, *Escherichia coli*, and aerobic spore formers).
8. Estimation of phosphate solubilizing capacity of microorganisms; Characterization of Plant Growth Promoting Rhizobacteria – Production of ammonia, IAA, siderophores, HCN, antibiotics, antifungal metabolites.
9. Isolation, identification and enumeration of AM fungal spores from soil.

PAPER-XXIII: Special Paper (Part – II) **FM = 40**

Special Paper– II: Biochemistry and Molecular Biology

1. Estimation of reducing sugar content by DNS method.
2. Determination of protein contents (by BCA and Bradford methods) of different plant samples.
3. Isolation and purification of enzyme.
4. Enzyme kinetic and inhibition study.
5. Evaluation of iso-enzymes by Native PAGE and its zymogram assay.
6. Evaluation and estimation of molecular weight of proteins by SDS PAGE.
7. Extraction and estimation of DNA from plant tissues by diphenylamine reaction.
8. Extraction and estimation of RNA from plant tissues by weevil reaction.
9. Quantitative estimation of DNA using UV spectrophotometer.
10. Evaluation of DNA and RNA in Agarose gels.
11. Restriction digestion of DNA and its analysis by Agarose gel electrophoresis.
12. Amplification of specific genes by PCR.

PAPER-XXIV: Project Work / Review and Seminar **FM = 40 + 20**

Work related to this course has to be done during Semester III and IV, but the dissertation has to be submitted at the end of Semester IV. Evaluation will be done through presentation by candidate followed by *viva voce*.

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