Syllabus for Post Graduate Course in Botany
(2016 – 2017 onward)
Department of Botany
Sidho-Kanho-Birsha University

Paper	Theory / Practical	Subjects	Credit / Paper	Total Credit
Semester-I				
Theoretical: Full Marks = 50 for each paper (20% of FM for internal assessment, attendance etc.)				
MBOTCCT - 101	Theory (Core)	Microbiology (2), Phycology (2)	4	24
MBOTCCT - 102	Theory (Core)	Mycology (2), Plant Pathology (2)	4	
MBOTCCT - 103	Theory (Core)	Bryology (2), Pteridology (2)	4	
MBOTCCT - 104	Theory (Core)	Biomolecules (2), Cell and Molecular Biology (2)	4	
Practical = 50, 30 (Practical work - continuous evaluation and attendance); 20 (Viva-voce and submission)				
MBOTCCS - 105	Practical (Core)	Phycology (1), Mycology (1), Bryology (1), Pteridology (1).	4	
MBOTCCS - 106	Practical (Core)	Microbiology (1.5), Plant Pathology (1), Cell and Molecular Biology (1.5).	4	
Semester-II				
Theoretical: Full Marks = 50 for each paper (20% of FM for internal assessment, attendance etc.)				
MBOTCCT - 201	Theory (Core)	Gymnosperms (2), Paleobotany and Palynology (2)	4	24
MBOTCCT - 202	Theory (Core)	Plant Anatomy and Developmental Biology (2) Pharmacognosy (2)	4	
MBOTCCT - 203	Theory (Core)	Genetics and Genomics (2), Plant Biotechnology(2)	4	
MBOTCCT - 204	Theory (Core)	Taxonomy of Angiosperms and Biosystematics (2), Ecology (2)	4	
Practical = 50, 30 (Practical work - continuous evaluation and attendance); 20 (Viva-voce and submission)				
MBOTCCS - 205	Practical (Core)	Gymnosperms (1), Palaeobotany and Palynology (1), Plant Anatomy & Developmental Biology (1), Pharmacognosy (1).	4	
MBOTCCS - 206	Practical (Core)	Genetics and Genomics (1.5), Taxonomy (1.5), Ecology (1).	4	
Semester-III				
Theoretical: Full Marks = 50 for each paper (20% of FM for internal assessment, attendance etc.)				
MBOTCCT - 301	Theory (Core)	Plant Physiology (2), Plant Biochemistry (2)	4	24
MBOTCCT - 302	Theory (Core)	Economic Botany (2), Bioinformatics (2)	4	
MBOTCCT - 303	Theory (Core)	Elements of Forestry (2), Seed Technology (2).	4	
MBOTOET - 304	Open elective	Course offer by other PG Department	4	
Practical = 50, 30 (Practical work - continuous evaluation and attendance); 20 (Viva-voce and submission)				
MBOTCCS - 305	Practical (Core)	Plant Physiology, Seed Technology and Plant Biochemistry (3); Forestry (1)	4	
MBOTOPP - 306	Social Outreach Program		4	

Semester-IV				
Paper	**Theory / Practical**	**Subjects**	**Credit / Paper**	**Total Credit**
Theoretical: Full Marks = 50 for each paper (20% of FM for internal assessment, attendance etc.)				
MBOTCCT - 401	Theory (Core)	Instrumentation (2), Biostatistics (2)	4	24
MBOTMET - 402	Theory (Major Elective)	Special paper –I	4	
MBOTMET - 403	Theory (Major Elective)	Special paper – II	4	
Practical = 50, 30 (Practical work - continuous evaluation and attendance); 20 (Viva-voce and submission)				
MBOTMES - 404	Practical (Major Elective)	Special paper	4	
MBOTMES - 405	Dissertation	Review / Project presentation on Major Elective paper.	4	
MBOTACT – 406	Add-on Course		4	

Δ Student will study Core Courses in all the semesters.
Δ Students will opt for any one of the Major Electives (Special Paper) in Semester-IV along with core course.
Δ Students will opt for any one Open Elective course in Semester-III offered by other P.G Departments.
Δ Students will undertake and actively participate in Social Outreach Programme in the Semester-III.
Δ Students have to submit a Project Work based on Major Elective in Semester-IV.
Δ Students will select one of the Add-on Course in Semester-IV offer by their own or other departments.

- **Major Elective Courses are:**
  1. **Paleobotany & Palynology.**
  2. **Taxonomy of Angiosperms & Biosystematics.**
  3. **Mycology and Plant Pathology.**

- **Open Elective Course offered by Botany Department: Sustainable Agriculture and Food Security**
- **Add-on Courses: Communicative Sanskrit, Statistical Analysis, Value Based Education, Communicative English, Computer Application, Indian Constitution, Book Keeping, Health, Hygiene, Sanitization, Environmental Protection and Management.**

- **SUMMARY OF COURSE AND CREDIT –**

Semester	Core Course		Major Elective Course		Open Elective Course	Project / Dissertation	Social Outreach Programme	Add-on Course	Total
	Theory	Practical	Theory	Practical					
I	**16**	**08**	**-**	**-**	**-**	**-**	**-**	**-**	**24**
II	**16**	**08**	**-**	**-**	**-**	**-**	**-**	**-**	**24**
III	**12**	**04**	**-**	**-**	**04**	**-**	**04**	**-**	**24**
IV	**04**	**-**	**08**	**04**	**-**	**04**	**-**	**04**	**24**
Total	**48**	**20**	**08**	**04**	**04**	**04**	**04**	**04**	**96**

Semester-I

MBOTCCT – 101

Theory (Core)

Group - A

MICROBIOLOGY **Credit- 2 (25 L.)**

1. History & Discoveries: Areas and scopes of microbiology. Establishment of different fields of microbiology. Contribution of different scientists (Anton von Leeuwenhoek, Joseph Lister, Paul Ehrlich, Edward Jenner, Louis Pasteur, Robert Koch, Martinus W. Beijerinck, Alexander Fleming, Selman A. Waksman, Norman Pace, Carl Woese, Ananda M. Chakraborty, Arber & Nathans)
2. Taxonomy & Phylogeny: Principle, characteristics used in the classification and identification of microbes. Classification of bacteria (according to Bergey's Manual). Modern trends of bacterial identification.
3. Diversity: Bacteria with unusual properties – Spirochete, Rickettsia, Chlamydia, Mycoplasma, Archebacteria, Myxobacteria and Actinomycetes. Extremophiles (thermophilic, halophilic, acidophilic, alkalophilic bacteria and their molecular mechanism of survival).
4. Morphology & Anatomy: Morphology of Eubacteria and Archaeobacteria, Cell wall, Flagella, Pili, Capsule, Cytoplasmic membrane, Endospore (Structure, cytology, physiology and genetic aspects), Nucleoid, Reserve substances. Principle of Gram and Acid fast staining.
5. Nutrition, Growth and Differentiation: Types of Culture media (Synthetic, Complex, Selective, Differential media), and enrichment culture, anaerobic culture, study of unculturable bacteria. Definition of growth, Growth Kinetics, Measurement of growth, Synchronous & Diauxic growth, Factors affecting growth, Batch and Continuous culture.
6. Metabolism: Bacterial Photosynthesis & Chemosynthesis. Outlines of Biosynthesis of Peptidoglycan, Major Amino acids and Proteins, Respiration and Fermentation, Fermentation pathway (ED pathway etc.), N_2 Fixation (Symbiotic & Non symbiotic). Gene regulation (Operon concept).
7. Genetics: Organization of Genetic material in bacteria, Chromosome and Plasmid, Replication of prokaryotic chromosomes, Genetic Recombination, Transposon, Gene-mapping and Complementation Test, Molecular basis of Mutation & Isolation of mutants.
8. Genetic Engineering: Vectors, RE, Host restriction modification, Gene cloning, Application of Genetic Engineering in Agriculture, Medicine and industry.
9. Environmental Microbiology: Microbial flora of Air, Water and Soil. Role of Microbes in Recycling of Nutrients, Water pollution, Parameters of Potable water, Water Purification in Municipal water supply, Domestic waste treatment systems,
10. Agricultural Microbiology: Microbial Pesticides, Microbial Biofertiliser, Microbial Degradation of Pesticides and Toxic Chemicals, Biodegradation of the Agricultural residues, Bioremediation of Contaminated soils and water, Biosensors & Biopolymers.
11. Food & Industrial Microbiology: Fermented foods, Commercial production of fermented Dairy products, Fermented Beverage, Fermented Vegetables, Probiotics and Prebiotics, Pharmaceuticals and Enzymes, Food Spoilage, Methods of Food Preservation, Microbes in recovery of Metal (Bioleaching) and Oil, Cell and enzyme immobilization.
12. Medical Microbiology: Pathogenic properties of Bacteria, Toxins and Extracellular Enzymes. Brief account of major human disease and their bacterial pathogens. Control of microorganisms by Physical, chemical and chemotherapeutic agents (a brief account with their mode of action), Bioassay of antibiotics.
13. Viruses and acellular microbes: Distinctive properties, Structural organization and Chemistry of viruses, Assay of Viruses, Nomenclature and Classification (ICTV), Viral Genome, Viral Replication and their Regulations,

14. Bacteriophage base Vectors for c-DNA and Genomic Libraries, Viruses as Disease producing agents, Oncogenesis, Antiviral drugs, Virus related agents (Viriods and Prions), HIV and its importance.
15. Immunology: 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. Antigens: Characteristics and Types, Structure and Functions, Adjuvant. Immunoglobulzs: Types, Structure and Properties. Different classes of Immunoglobulins, MHC, Mechanism of Immune Response. Serological Reaction (Precipitation, Agglutination, Compliment fixation), Opsonisation, Hypersensitivity – Types. Vaccines – Overview, Types (Attenuated, Toxoid, Split Vaccine, Recombinant vaccine, Edible vaccine). Immunological Techniques (Monoclonal antibody, ELISA).

Group - B

PHYCOLOGY **Credit- 2 (25 L.)**

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 habitats and their conservation.
3. Cyanobacteria: Protoplasmic structures, genome and genetic properties; ultra structure of heterocyst, biochemistry of *nif* gene regulation; ecology, cyanophages.
4. General overview of algal divisions: Diagnostic characters of major algal divisions-
   Glaucophyta-Principle characteristics and primitive features
   Dinophyta- Cell structure; heterotropism.
   Chlorophyta-Cell division patterns, ultra structure of flagella; classification and phylogeny.
   Charophyta-features, phylogeny and their role in origin of land plants.
   Bacillariophyta-Ultra structure and developmental patterns of diatom frustules
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 applications; microalgal food.
7. Algal phenomena and their ecological significance: Algal blooms, El Nino, red tides and bioluminescence.

MBOTCCT - 102

Theory (Core)

Group - A

MYCOLOGY **Credit- 2 (25 L.)**

1. Introduction: Origin, Phylogeny and Evolution of Fungi. Modem concept regarding their placement.
2. Ultrastructure of fungal cell, Architecture and Synthesis of Cell wall. The cytoskeleton, Fungal growth, Secretory route and membrane trafficking, Nutrient uptake.
3. Sporulation – types, factors affecting sporulation, spore liberation and dispersal.
4. Sexual Reproduction in Fungi. Homothallism, heterothallism, molecular basis of mating systems, mating systems in Basidiomycota, parasexuality.
5. General account of Myxomycota, Mastigomycota, Zygomycota, Ascomycota, Basidiomycota and mitosporic fungi.
6. Role of fungi in industrial production of food, Antibiotics, Organic acids, Plant growth regulator, alcohol and enzyme production.
7. Mushroom cultivation – Types, preparation of substrate for cultivation, food value, common diseases and control of mushrooms.

8. Mycorrhiza - Types, Distribution of AM fungi and their role, molecular mechanism involved in signaling for mycorrhization and signal transduction pathway. Application of Mycorrhiza in agriculture & forestry.
9. Endosymbionts –Types, ecology and their importance.
10. Mycotoxins - General account (Types, sources, detection, clinical information of mycotoxicosis, mode of action).
11. Lichenized fungi – Morphology and reproduction. Establishment of lichen thallus. The nutritional basis of Lichen symbiosis. Lichenicolous fungi. Ecological and Economic importance.

Group – B

PLANT PATHOLOGY

Credit- 2 (25 L.)

1. History and development of plant pathology.
2. Molecular events in plant defense: Signal transduction during plant-pathogen interaction, Mechanism of penetration and the process of disease development.
3. Seed deterioration: Factors, effect, fungal succession and control of seed deterioration.
4. Plant diseases caused by environmental factors: Effect of temperature, moisture, light, oxygen, minerals, pollutants, agricultural practices and chemicals.
5. Fungal toxins: Host non selective toxins, Host specific toxins - structure, and mode of action.
6. Plant disease epidemiology: Elements of epidemic, factors, forecasting and support systems. Plant quarantine – Rules and practice.
7. General account of fungal, viral and bacterial disease management. Chemical control - General account of Systemic fungicides including classification, methods of application, uptake and translocation, mechanisms of action & drawbacks.
8. Recent advances in Plant disease control: biological methods, systemic acquired resistance, genetic engineering, and integrated control of plant diseases.
9. Symptoms, etiology and control measures of some important diseases of Paddy, Corn, Onion, Tomato and Sugarcane.

MBOTCCT - 103

Theory (Core)

Group - A

BRYOLOGY **Credit- 2 (25 L.)**

1. General habit, habitat, diversity, **biogeography** and **conservation of Bryophytes**.
2. Origin and evolution of Bryophytes.
3. Outline of recent classification of Bryophytes.
4. Fossil bryophytes: Characteristics, affinities and systematic position.
5. Morphology and developmental anatomy of gametophytes of Marchantiophyta, Anthocerotophyta and Bryophyta *Sensu stricto.*
6. Sporophyte organization and its evolutionary significance in bryophytes: Peristome structure and its taxonomic significances.
7. Ecology of bryophytes and role in monitoring of pollution. Bryophytes as site-specific bio-indicator and phytoremediator.
8. Cytogenetics and Biotechnology of Bryophytes.
9. Economic importance of Bryophytes.

Group - B

PTERIDOLOGY **Credit- 2 (25 L.)**

1. Introduction; Outline of systematic treatments of Pteridophytes; distribution of extant and extinct groups in time and space.
2. Characteristic features, geological distribution, evolutionary trends and interrelationships of Rhyniopsida, Zosterophyllopsida, Trimerophytopsida, Psilopsida, Lycopsida and Sphenopsida.
3. Stomatal types and development; Stelar organization and evolution; ecology, karyology and affinity of Ophioglossaceae, Osmundaceae, Cyatheaceae, Polypodiaceae, Salviniaceae; soral evolution in ferns.
4. Types of spore and induction of spore germination, gametophyte types, biochemical aspects of gametophyte differentiation; phytochemistry of pteridophytes.
5. Cytology and reproductive biology of ferns: Polyploidy, apospory, apogamy, genetic load; mating systems in ferns; Sexuality in homosporous pteridophytes with special reference to antheridogens activity (chemical nature and mode of action); vivipary in pteridophytes.
6. Diversity of ferns in ecological perspective; insect, microorganism-pteridophyte interactions, Endangered and endemic pteridophytes and their conservation.
7. Economic importance of Pteridophytes

MBOTCCT – 104

Theory (Core)

Group - A

BIOMOLECULES **Credit- 2 (25 L.)**

1. Fundamental concepts of chemistry for explaining the properties of biomolecules: Chemical bonds, stabilizing interactions (Vander wall's, electrostatic, H-bonding, hydrophobic interactions), biophysical chemistry (pH, buffer, reaction kinetics, colligative properties)
2. Chemistry of primary metabolites: Protein, DNA, RNA, carbohydrate, lipid.
3. Conformation of Protein: Hierarchical structure, domain, motif, folds, chaperon and protein folding.
4. Nucleic acids: Structure, occurrence and functions of A, B, Z – DNA, t-RNA, m-RNA, micro RNA.
5. Biochemical techniques: Purification and characterization of biomolecules (protein and nucleic acids).
6. Fundamentals of proteomics, metabolomics and genomics.

Group - B

CELL AND MOLECULAR BIOLOGY **Credit- 2 (25 L.)**

CELL BIOLOGY

1. Origin of life: An overview, endosymbiotic origin of mitochondria and chloroplast; origin of biomolecules, primitive life forms, RNA world, concept of ribozyme and evolution of enzymes; Tree of life: rRNA as a chronological marker.
2. Cellular organization: Structure of cell organelles - An overview, Cell wall and membrane structure; Membrane constituents- phospholipids, glycolipids, cholesterol, membrane proteins; receptors and phospholipases; Phospholipid bilayer- structure, asymmetry, fluid mosaic model of random diffusion of membrane components, domains in membrane- natural and artificial membranes passive movements of

solutes, ion distribution; mediated permeation; ionophores; membrane transport of small molecules and the ionic basis of membrane excitability; principles of membrane transport; carrier proteins and active membrane transport; ion channels and electrical properties of membranes, Cell junctions and cell adhesion molecules; basement membrane; extracellular matrix.

3. Cell cycle and its regulation: Cell cycles check points and regulation in *S. cerevisiae* and *S. pombe*.

MOLECULAR BIOLOGY

1. DNA replication, repair and recombination, RNA synthesis and processing, Protein synthesis and processing.
2. Gene expression: Principles of gene regulation; Regulation of gene expression in prokaryotes and eukaryotes.
3. DNA topology, DNA damage and repair transcription, processing, regulation, post-transcriptional control and gene silencing.
4. Plant genes, promoters, intron splicing, vectors, codon optimization, gene mapping and cloning of plant genes.
5. Recombinant DNA technology: Principles and methods of recombinant DNA technology- expression of cloned genes in *E. coli*, cloning in yeast: transformation in yeast, yeast artificial chromosome (YAC), retrovirus like vector (Ty) in yeast/shuttle vector, Molecular improvement of crops.
6. Signal perception Molecular mechanisms of signal perception, transduction and regulation.

MBOTCCS – 105

Practical (Core)

PHYCOLOGY (Credit: 1)

1. Identification of commonly occurring freshwater algal genera under prescribed groups.
2. Identification of seaweeds from different divisions - Chlorophyta, Phaeophyta, Rhodophyta.
3. Phytoplankton sampling and identification.
4. General principles of culturing algae in laboratory and growth measurement.
5. Collection of local flora; Field record and specimen to be submitted (minimum 15 specimens).

MYCOLOGY (Credit: 1)

1. Principles and uses of instruments.
2. Different types of culture media and their preparation. Preparation of stabs, slants and pouring of plates.
3. Isolation of fungi from water/soil/air by culture plate technique.
4. Isolation and identification of phylloplane fungi.
5. Preparation of pure culture and sub culturing.
6. Preparation of spawn and cultivation of *Pleurotus.*
7. Study of vegetative and reproductive structures (including measurement of reproductive parts) of *Phytophthora sp, Saprolegnia sp, Aspergillus sp, Clavaria sp, Auricularia sp, Curvularia sp and Trichoderma sp.* Practical note book, photographic documentation and preserved specimens with field record of excursion to be produced during practical examination.

BRYOLOGY (Credit: 1)

1. Studies of Vegetative, Reproductive structures and Identification up to the Generic level (using a suitable key) of: Marchantiophyta: Thallose and Foliose members - at least 6 specimens;
   Bryophyta: Nematodontous, Arthrodontous (Both haplolepidous and Diplolepidous) and Cleistocarpic – at least 6 specimens.
2. Students are required to submit field and laboratory records, specimens (not more than 10 specimens) and permanent slides.

PTERIDOLOGY (Credit: 1)

1. Morpho-anatomical and reproductive structures of the members of following families: Isoetaceae, Polypodiaceae, Thelypteridaceae, Pteridaceae, Athyriaceae, Gleicheniaceae, Cyatheaceae, Blechnaceae, Salviniaceae and Marsileaceae.
2. Study of diagnostic features of following important taxa:
   Psilotum sp., *Lycopodium squarrosum, L. selago, Ophioglossum* sp., *Marattia* sp., *Drynaria sp., Acrostichum sp., Selaginella bryopteris, Equisetum* sp., *Pteris vittata, Pyrrosia* sp., *Helminthostachys zeylanica*, *Cheilanthes* sp., *and Onychium* sp.
3. Detection and bioassay of allelopathic substances of fern.
4. Field works; Submission of field and laboratory records including permanent slides; collection and preservation of common taxa (Maximum 10).

MBOTCCS – 106

Practical (Core)

MICROBIOLOGY (Credit: 1.5)

1. Methods of sterilization, idea about microbiological instruments and preparation of different types of culture media.
2. Gram staining, negative staining and endospore staining.
3. Methods of isolation of pure culture by streak plate, pour plate and spread plate method.
4. Study of *Rhizobium* (using Yeast extract Mannitol Agar), *Azotobacter* (using Ashby's Mannitol Agar) and Actinomyces (using Glucose Aspergine Agar).
5. Measurement of bacterial growth by turbidimetry & direct cell count by haemocytometer.
6. Determination of antibiotic sensitivity of some bacteria by disc diffusion method.
7. Study of catalase and amylase activity in bacteria.
8. Presumptive test for coliform group of bacteria from water (MPN method).
9. Blood grouping by kit.
10. Visit to some industries of microbiological interest. Field record with herbarium sheets of bacteria and virus infected plants must be submitted during practical examination.

PLANT PATHOLOGY (Credit: 1)

1. Preparation of culture media (synthetic, semi-synthetic and complex), Preparation of stabs, slants and pouring of plates.
2. Isolation of pathogen from diseased plant parts.
3. Pure culture and Sub culturing technique
4. Determination of fungicide sensitivity of some fungi by agar well method.
5. Symptomatology & histopathological studies of fungal diseases of economically important crops.
6. Students are required to submit field record, laboratory note book, preserved specimens and permanent slides during practical examination.

CELL AND MOLECULAR BIOLOGY (Credit: 1.5)

1. Sub-cellular fractionation of plant tissues and isolation of cellular organelles.
2. Protein and nucleic acid (RNA and DNA) isolation and purification from plant tissue.

3. Isolation of plasmid and genomic DNAs (Demonstration).
4. Demonstration of Mol Biology tools: Electrophoretic techniques (1D, 2D); Chromatographic Techniques (Paper, Thin Layer, HPLC, GC), Restriction Mapping, RAPD, Transformation, PCR, SEM, Confocal and TEM.

Semester-II

MBOTCCT – 201

Theory (Core)

Group - A

GYMNOSPERMS **Credit- 2 (25 L.)**

1. Geological distribution, classification, range of vegetative and reproductive structures of Progymnospermopsida and its evolutionary significance.
2. General features of gymnosperms; Current concepts on classification of Gymnosperms up to order with brief characterization of orders. Distribution of extant members of Gymnosperms in India.
3. Diagnostic features, classification, distribution in time and space and evolutionary trends of the following orders:
   a) Pteridospermales, b) Cycadeoidales, c) Caytoniales, d) Glossopteridales, e) Pentoxylales
4. Vegetative morphology and reproductive biology (pollination mechanism, embryology) of extant Cycadales, Coniferales, Ginkgoales, Taxales and Gnetales.
5. Karyology, phytochemistry and biotechnology of important taxa, biotechnogy of important taxa; endangered and endemic taxa and their conservation; Gymnosperms as a source of wood, resins, essential oils, food and drugs.

Group - B

PALEOBOTANY AND PALYNOLOGY **Credit- 2 (25 L.)**

1. Basic geological information: Sedimentary rocks; Taphonomy; Fossil: types and mode of preservation, conditions of preservations; Nomenclature and reconstruction of fossil plants; Dating of rocks: relative dating by fossils, absolute dating (radiometry); Stratigraphy; Basic concepts of continental drift and plate tectonics.
2. Origin and evolution of plant life: The earliest environments; Brief idea of Origin of life; first prokaryotes; evolution of eukaryotes; geological records of algae (stromatolites, diatoms, dinoflagellates), fungi (endomycorrhiza and epiphyllous fungi), and their ecological significance.
3. The colonization of land: Environmental changes before terrestrialization, land adaptive features, evolution of land plants- different evidences.
4. Emergence and evolution of seed bearing plants:

a) Preovules, hydrasperman reproduction; evolution of closed carpel; evidences from the ovulate fructification of Glossopteridales, Corystospermales, Caytoniales, Bennettitales, Pentoxylales.

b) Evidence for the first angiosperms: leaves, flowers and pollen grains; place of origin and radiation.

5. Applied palaeobotany:

a) Fundamentals of palaeofloristics, palaeogeography, palaeoecology and palaeoclimatology.

b) Life as fuel maker: Organic deposits of commercial value- coal, petroleum-their origin and depositional environment; coal and petroliferous basins of India.

c) Ancient DNA and other fossil biomolecules and their potential in evolutionary research; stable isotopes and tree ring in reconstruction of palaeoclimate.

6. Palynology:

a. Branches of palynology; Spore and pollen morphology: polarity, symmetry, shape, forms of apertures and their evolution; structure and sculpture of sporoderm, sporopollenin, extra-exinous wall material; NPC system; Pre-pollen; concept of non-pollen palynomorphs

b. Application of neopalynology and palaeopalynology; melissopalynology, archaeopalynology, forensic palynology, aeropalynology.

MBOTCCT – 202

Theory (Core)

Group - A

PLANT ANATOMY & DEVELOPMENTAL BIOLOGY **Credit- 2 (25 L.)**

PLANT ANATOMY

1. Differentiation of primary and secondary plant bodies: Origin and development of sclereids and fibres and their control of differentiation.
2. Organization of shoot and root apical meristems. Changes in shoot apex during transition to flowering.
3. Development and differentiation: Polarity, symmetry, pattern formation (brief idea of genetic control of differentiation and organogenesis).
4. Origin, differentiation and phylogeny of xylem and phloem.
5. Leaf morphogenesis (brief idea of genetic control of differentiation and organogenesis).
6. Ultra structural features of sieve tube elements and their importance.
7. Ecological anatomy: Leaf and wood anatomy in ecological perspective; anatomical responses to pollution.

DEVELOPMENTAL BIOLOGY

1. General Aspects: Novel features of plant growth and development; concepts of plasticity in plant development; analyzing plant growth.
2. Archegoniatae: Comparative morphology and developmental anatomy of Hepaticae, Anthocerotae and Musci; comparative anatomy of vegetative organs of Pteridophytes., origin and pattern of development of cortex and procambium in conifers.
3. Fertilization and early development in plants; fertilization, post-fertilization changes, axis and pattern formation in Arabidopsis.
4. Male gametophyte: Microsporogenesis, **role of tapetum**; pollen development and gene expression; male sterility; sperm dimorphism and hybrid seed production.
5. Female gametophyte: Ovule development; megasporogenesis; organization of the embryo sac, types of embryo sacs, **structure of embryo sac cells.**
6. Polyembryony- Definition, causes, classification and practical value.
7. Apomixis: Gametophytic apomixis, diplospory and apospory.

Group - B

PHARMACOGNOSY **Credit- 2 (25 L.)**

1. Pharmacognosy: Definition, history and scope.
2. Systems of classification of drugs of natural origin.

3. Importance of Crude drug; Preparation of drugs for commercial market: Collection, harvesting, drying, garbling, packaging, storage and preservation.
4. Morphological and chemical (brief idea) characteristics of different drug plants producing carbohydrates, alkaloids, glycosides and other secondary metabolites.
5. Metabolic pathways generating medicinally important secondary metabolites.
6. Adulteration and quality control of plant drugs.
7. Importance of Traditional Medicines in novel development of medicines (Synergy & drug attenuation).

MBOTCCT – 203

Theory (Core)

Group - A

GENETICS AND GENOMICS **Credit- 2 (25 L.)**

1. Basic concepts in Genetics: Discoveries in classical and molecular genetics; Extension of Mendelism: Allelism; gene-environment interaction; penetrance and expressivity; epistasis, pleiotropy, continuous and discontinuous variations; complementation test for alleles; physical and chemical basis of equational separation of chromosomes; recombination, Mechanisms and genetic control of recombination; Evolutionary significance of recombination. Mutagenesis: Molecular basis of spontaneous and induced mutations; Transposon mutagenesis, Site-directed mutagenesis, Structure and function of transposable elements and their role in evolution.
2. Population Genetics: Gene frequency in a population, genetic equilibrium, Hardy- Weinberg principle, barriers to gene flow and mechanism of speciation, Inbreeding and genetic consequences of self-pollination in plants.
3. Genome organization in Eukaryotes: Types of genomes, genetic features of eukaryotic nuclear genomes; development of gene concept, gene replication, organization of structural and functional elements of chromosome - centromere, telomere heterochromatin and telomerase, sex chromosomes in plants; special chromosomes in different eukaryotes ; genome duplication and alterations and their role in evolution; Law of constancy and C-value paradox.
4. Genomes and Comparative Genomics: Nuclear, mitochondrial and chloroplast genomes of Eukaryotes: physical features and genetic content; Concept of mapping and sequencing of genomes, Genome annotation; Synteny; Gene search and comparison tools.
5. Functional Genomics -- Approaches to analyze differential expression of genes - ESTs, SAGE, microarrays and their applications; Principles in reverse genetics: Gene tagging; Gene trapping; Gene silencing; Knockout mutants; Transcriptome; Ribotype concept; concept, methodology and applications of proteomics.

Group – B

PLANT BIOTECHNOLOGY **Credit- 2 (25 L.)**

1. Plant Breeding: Conventional breeding methods for self-pollinated, cross-pollinated and vegetatively propagated crop plants. Heterosis breeding. Polyploidy and haploids in plant breeding. Advantages and limitations.
2. Marker assisted breeding: Introduction - molecular markers as new efficient tools in breeding. Marker aided selection – foreground and background selection, concept of graphical genotypes, elimination of linkage drags.

3. Plant tissue culture and somatic cell genetics: Plant regeneration pathways - Organogenesis and Somatic embryogenesis; Endosperm culture and triploid production; Anther and pollen culture, and production of haploid and doubled haploid plants; Protoplast culture and fusion, Somatic hybrids; Organelle transfer and cybrids; Micropropagation, artificial seed and bioreactor technology, Virus free plants by meristem culture; Use of somaclonal and gametoclonal variation for crop improvement; In vitro mutagenesis and mutant selection; Preservation of plant germplasm in-vitro.
4. Plant transformation vectors and methods: Plant transformation vectors - T-DNA and viral vectors, direct gene transfer vectors; Selectable marker and reporter genes, Plant transformation by *Agrobacterium* sp., non-*Agrobacterium* sp., and in plant transformation, Molecular mechanism of T-DNA transfer; Direct gene transfer methods in plants - Gene gun and other methods; Chloroplast transformation; Transgene analysis, silencing and targeting; Marker-free and novel selection strategies; Multigene engineering; Gene tagging; Gene knock-down by ribozymes, antisense RNA and RNA interference.
5. Applications of plant transgenic technology: Transgenic crops for resistance against biotic and abiotic stresses; Engineering crops for male sterility and modification of flower colour, fruit ripening and senescence; GM crops for nutritional quality and quantity; RNAi-mediated crop improvement; Molecular pharming; Metabolic engineering and hairy root culture for secondary plant products; Other applications; Global status and biosafety of transgenic plants.

MBOTCCT – 204

Theory (Core)

Group - A

TAXONOMY OF ANGIOSPERMS AND BIOSYSTEMATICS: **Credit- 2 (25 L.)**

1. Introduction: Systematics, Taxonomy, Classification, Identification, Nomenclature.
2. International Code of (Botanical) Nomenclature (ICBN/ICN): History, aims and principles, brief knowledge of rules and recommendations with selected examples.
3. Tools of Taxonomy: Field collection methods, Herbarium, Botanic Gardens and their importance in teaching and research, GIS (Geographical Information System) in Botany, Brief knowledge of Taxonomic literature.
4. Data sources of Taxonomy: Anatomy, embryology, palynology, cytology and phytochemistry.
5. Species concept.
6. Numerical Taxonomy (Phenetics): Definition, Principles, Steps of studies, Merits and Demerits.
7. Cladistics: Definition, Principles, Merits and Demerits.
8. Major systems of classification and their merits and demerits: Cronquist's system (1981), Takhtajan's System (2009), APG IV Classification (2016).
9. Angiosperms diversity: Salient features, phylogeny and evolutionary trends in Magnoliales, Hamamelidales, Caryophyllales, Asterales, Alismatales, Pandanales, Cyperales and Orchidales.
10. Biodiversity: Concept, levels, values, hotspots and hottest hotspots, megadiversity centers of world, loss of biodiversity, IUCN threat categories, *in situ* and *ex situ* conservation measures.

Group – B

ECOLOGY **Credit- 2 (25 L.)**

1. Introduction: Significance and scope of ecology.
2. Population Ecology: Characteristics of population, population size and exponential growth, factors affecting population growth, population dynamics.

3. Community ecology: Nature of communities; community structure and attributes; levels of species diversity and its measurement; edges and ecotones. *Community dynamics*- Ecological succession, attributes and different models.
4. Species interactions: Types of interactions, interspecific competition, herbivory, carnivory, pollination, symbiosis.
5. Plant Adaptation: Adaptive features of Hydrophytes, Xerophytes, Halophytes & Epiphytes.
6. Ecological indicators: Characteristic features, types and uses.
7. Wetland: Definition, classification, its role in nature and conservation; Ramsar sites, Common wetland flora of West Bengal.
8. Environment problems & management: General account of Environmental pollution with special reference to climate change, ozone layer depletion, acid rain, fluoride, arsenic & heavy metal poisoning, solid waste, plastics, oil spill, SPM, coastal and marine pollution. Strategies to combat environmental pollution.
9. Environmental laws and regulations: Environmental impact assessment, Environmental (protection) Act, 1986: Water (prevention and control of pollution) Act, 1974: Forest conservation Act, 1980: Wildlife protection Act, 1972, National green tribunal.

MBOTCCS – 205

Practical (Core)

GYMNOSPERMS (1)

1. Study of external and internal morphology of reproductive structures of Conifers (*Pinus*, *Tsuga*), Cycads (*Cycas*, *Zamia*) and Gnetales (*Ephedra*, *Gnetum*).
2. Study of leaf and wood anatomy of the following taxa: *Cycas*, *Abies, Cryptomeria, Cupressus, Araucaria, Gnetum*.
3. Study of important fossil Gymnosperms from prepared slides and specimens.
4. Field works; Submission of field and laboratory records including permanent slides; collection and preservation of common taxa (Maximum 10).

PALEOBOTANY AND PALYNOLOGY (1)

1. Types of fossils and modes of preservation.
2. Techniques of study of plant fossils: Thin section method (demonstration and study of prepared slides), peel techniques (demonstration and study of prepared peel sections); maceration of peat, lignite, coal: (demonstration).
3. Systematic study of fossil plants through ages- Stromatolites, Precambrian biota, *Cooksonia, Rhynia, Lepidodendron*, *Sigillaria, Lepidophlois, Sphenophyllum, Calamites,* members of Filicopsida-Coenopteridales members of Lyginopteridales, Medullosales, Glossopteridales: *Vertebraria* root, Bennettitales, Cycadales, Ginkgoales, Pentoxylales, Cordaitales, Coniferales. Tertiary and Quaternary angiosperm plant remains.
4. Acetolysis method (demonstration); Studies of morphology of modern spores (Pteridophytes) and pollen grains (Gymnosperms and Angiosperms); Extraction of pollen grains from honey samples and study of the frequency of different morpho-types.
5. Study of macerated sample (to be supplied) of peat, lignite and coal. Quantitative and qualitative study of palynomorphs; Interpretation of data on stratigraphic age and environment of deposition.
6. One visit to Palaeobotany-Palynology Laboratory inside India and / or field study is . Practical records regularly checked, and permanent slides prepared during practical classes should be submitted at the term-end examination.

PLANT ANATOMY & DEVELOPMENTAL BIOLOGY (1)

1. Study of unilacunar, trilacunar, multilacunar.
2. Wood anatomy (xylotomy) as revealed through TS, TLS, RLS of woody plants.
3. Anatomy of sun and shade leaves, xeromorphic leaves, succulent leaves, hydromorphic leaves.
4. Study of phloem by maceration technique.
5. Study of different types of stomata (monocots and dicots).
6. Study of laticifers, oil cavity, resin ducts.
7. Study of morphology and anatomy of thalloid and leafy forms of Bryophytes; Study of protonema.
8. Study of fern gametophyte and soral variations.
9. Comparative anatomy of conifers and Gnetales.
10. Study of in vitro and in vivo germination of Pollen grains.
11. Study of the stages of pollen and ovule development using permanent slides.
12. Submission of laboratory records and permanent slides.

PHARMACOGNOSY (1)

1. Organoleptic study of some important crude drugs including unorganized drugs - resins, latex, oils etc.
2. Chemical tests for the detection of alkaloids, phenols, anthraquinones, cardenolides, anthocyanins, betacyanins, carotenoids.
3. The fluorescence characteristics of powdered drug samples treated with inorganic acids and solvents under ordinary light and UV light.
4. Antioxidant properties of some medicinal plants.
5. Submission of Field record & Laboratory note book and 10 medicinal plants (minimum) is required during practical examination.

MBOTCCS – 206

Practical (Core)

GENETICS AND GENOMICS (1.5)

1. Meiosis: Study of chromosome pairing in diploids (*Allium, Datura, Setcreasea*), polyploids *(A. tuberosum*) and structural hybrid (*Rhoeo* sp.) and determination of chromosome number.
2. Mitosis: Staining technique and karyotype analysis (*Lens* sp., *Allium* sp.).
3. Analysis of molecular polymorphism in parental lines and derived mapping population using different types of molecular markers.
4. RNA isolation, c-DNA preparation, gene amplification.
5. Frequency distribution analysis of probability, distribution and testing goodness of fit.
6. Estimation of heritability and genetic advance, ANOVA, ANCOVA, correlation coefficient.

TAXONOMY OF ANGIOSPERMS AND BIOSYSTEMATICS (1.5)

1. Application of taxonomic methods for identification of Species of different families of angiosperms.
2. Field excursion for familiarization with and study of vegetation type (s) and flora (s) of areas outside the state, and in the local areas.
3. Submission of herbarium specimens, field note book and laboratory records.

ECOLOGY (1)

1. Application of quadrat method in determining:
    a) Species-area relationship
    b) Important Value Index (IVI)
2. Estimation of organic matter, Nitrogen and phosphate of soil.
3. Estimation of dissolved oxygen content in the water sample by Winkler's method.
4. Determination of primary production in water samples by light and dark bottle method (Winkler's method).
5. Field study in selected ecosystem.
6. Submission of Field record & Laboratory note book.

Semester-III

MBOTCCT – 301

Theory (Core)

Group – A

PLANT PHYSIOLOGY **Credit- 2 (25 L.)**

1. Plant cells and water: Thermal properties of water, polarity, concept of osmosis, water potential and dynamic flux of water, aquaporins and cellular movement of water.
2. Solute transport and photoassimilates translocation: Uptake, transport and translocation of ions, solutes and macromolecules, loading and unloading of photoassimilates.
3. Current concept of plant growth regulators and phytohormones: Phytohormone families and members of each family, growth promoting and retarding chemicals, general mode of phytohormone action, hormone binding receptor proteins, second messengers, gene activation, examples of target cells for hormone action, brief idea about modern techniques for hormone assay. Chemistry and metabolism of IAA, GA, CK, ABA, Ethylene – receptors and their mutant study for signaling, molecular mechanism of signaling. Brassinosteroids – chemical nature, synthesis, deactivation, receptors and signaling of brasinolide.
4. Secondary metabolites: Biosynthesis, physiology and role of terpenes, glycosides, phenylpropanoids and alkaloids.
5. Bud and Seed Dormancy: Environmental signals for induction and breaking bud dormancy. Types, control mechanism, methods of breaking seed dormancy, biological significance of dormancy.
6. Photoperiodism and biological clock: Photoperiodic control, hormonal regulation, experimental evidences of mobile nature of flowering stimulus, gene induced regulation of floral development, ABC model, second messenger and flowering.
7. Senescence: Types, biochemical indices, physio-biochemical changes during leaf senescence, senescence regulatory genes, ROS and senescence.
8. Fruit development: Climacteric and nonclimacteric fruits, hormonal regulation of fruit set and ripening, biochemical changes during fruit ripening.

Group – B

BIOCHEMISTRY **Credit- 2 (25 L.)**

1. Carbohydrate metabolism : Glycolysis - control and significance, TCA cycle and its control, pentose phosphate pathway- control and significance, Gluconeogenesis - control and significance, Glyoxalate cycle – control and significance.

2. Amino acid and Protein: Classification and structures of amino acids, properties, determination of amino acid sequence in a polypeptide. Hierarchical structural organization of protein, post translational modifications of protein, chaperone and protein folding, protein targeting, Ramachandran plot.
3. Lipids metabolism: Biosynthesis and β-oxidation of fatty acids with energetics.
4. Enzyme kinetics: Deduction of Michaelis-Menten equation, Lineweaver-Burk plot; enzyme inhibition, isozymes, allosteric enzymes, ribozymes.
5. Photobiology of plants: Different modes of CO_2 concentrating mechanisms, their energetics and significance. Photorespiration - Compartmentalized reactions, regulation, their energetics and significance, structural and functional characteristics of Rubisco and its regulation.
6. Photoreceptors and Photomorphogenesis: Types and chemistry of photoreceptors in plants, their role in developmental responses, molecular consequences of phytochrome and cryptochrome signal transduction.
7. Cell signaling: Signal perception, G-protein coupled receptors, molecular mechanism of signal transduction and regulation. Tyrosine, Serine, Threonine and Histidine Kinases mediated signalling pathways
8. DNA and RNA metabolism, DNA damage , repair, transcription , translation, their regulation , post translational modification and gene silencing.
9. Fundamental of Omic Science – Basic concept of Proteomics, Genomics and Metabolism & their application.

MBOTCCT – 302

Theory (Core)

Group - A

ECONOMIC BOTANY **Credit- 2 (25 L.)**

1. Types and uses of natural resources with reference to minerals, wildlife, fresh water and marine resources. Plant products of industrial value. Lower plants in economic botany.
2. World centres of primary diversity and secondary centres of cultivated plants.
3. Non-Timber Forest Produce- types and uses with examples.
4. Current research in major cereals, oilseeds, legumes, medicinal plants, forest trees and non-alcoholic beverages.
5. Locally important Plant Genetic Resources (PGR) – *Zea mays, Cajanus cajan, Cicer arietinum, Sacharum officinarum, Arachis hypogea.*

Group - B

BIOINFORMATICS **Credit- 2 (25 L.)**

1. Introduction to bioinformatics – Applications and prospects, Bioinformatics Policy of India (2004), difference between bioinformatics and computational biology.
2. Sequence data bank - Introduction to sequence data bank, NBRF-PIR, SWISSPROT, Genbank, EMBL, Structural Databank: protein data bank (PDB), Biological sequence database, computer programming in bioinformatics, sequence analysis, pair wise alignment, multiple alignment, database similarity searching, algorithms of FASTA and BLAST, scoring matrices. Molecular evolution, molecular phylogenetics and construction of phylogenetic tree.
3. Structural Bioinformatics –Sequence pattern, motifs and profiles, SCOP, CATH. Prediction of secondary structure of protein.
4. Systems biology: Approaches and application.

MBOTCCT – 303

Theory (Core)

Group – A

ELEMENTS OF FORESTRY **Credit- 2 (25 L.)**

1. Forest: Definition, Classification of Indian forests according to Champion and Seth (1968) with their characteristic species.
2. Principles and objective of Forestry and silviculture.
3. Factors affecting forest vegetation (climatic, topographic, edaphic and biotic).
4. Resources (NTFP) and services provided by forests. Conservation and Sustainable forest management, sacred groves and their importance.
5. Ethnobotany and its importance in forest conservation.

Group – B

SEED TECHNOLOGY **Credit- 2 (25 L.)**

1. Development of typical monocot and dicotyledonous embryos; endosperm development, modification of food storage structures with reference to crop plants; different types of embryos, endosperm and cotyledons; development and their structure in representative crop plants; external and internal features of monocot and dicot seed; seed coat structure and development.
2. Physiology of seed development and maturation; chemical composition, synthesis and accumulation of seed reserves, induction of desiccation tolerance, hormonal regulation of seed development.
3. Seed viability and longevity, pre and post-harvest factors affecting seed viability; seed ageing; physiology of seed deterioration ; Oxidative damage and other viability theories; means to prolong seed viability; Seed vigour and its concept, vigour test methods, factors affecting seed vigour, physiological basis of seed vigour in relation to crop performance and yield. Seed invigoration and its physiological and molecular control.
4. Role of microorganisms in seed quality deterioration; management of seed borne plant Pathogens /diseases and procedure for healthy seed production; different seed health testing methods for detecting microorganisms.
5. Seed storage: Seed drying and storage; drying methods-importance and factors affecting it, changes during storage, concepts and significance of moisture equilibrium, methods of maintaining safe seed moisture content. Methods to minimize the loss of seed vigour and viability; factors influencing storage losses.
6. Viability and Vigour Testing: definition and importance of viability tests; different viability tests; quick viability test (TZ- test) - advantages, principle, preparation of seeds and solutions, procedure, evaluation and calculation of test results. Vigour testing: concept, historical development, definitions, principles and procedures of different methods used for testing vigour.
7. Aspects of seed quality evaluation and their relevance to crop performance. ISTA and its role in seed testing.

MBOTOET – 304

OPEN ELECTIVE COURSE (Theory)

⁎ Course for other PG Department students ⁎

SUSTAINABLE AGRICULTURE AND FOOD SECURITY — Credit- 4 (50 L.)

1. Introduction: Pillars of sustainability, indicators and concept of food security.
2. The science of global warming and climate change: Kyoto Protocol - Its principles, aims and achievements. Sources of GHG and the contribution of farming to those emissions. GHG mitigation policy for the agriculture sector. Carbon sequestration.
3. Biodiversity and ecosystem services: Biodiversity – types, importance giving emphasis on understanding of how biodiversity is important for our existence in terms of crops and livestock, pollination of crops, plant protection, food, fuel, water, recreation and other ecosystem services. Loss of biodiversity and prevention, various biodiversity database for sustainable farming.
4. Ecological & Sustainable Perennial Crop Production Systems: Introduction to perennial crop production. Planning and establishing ecological perennial crop orchards. Ecological infrastructure in ecological perennial crop orchards - sustainability and bio diversity indicators.
5. Sustainable soil management: Physical, chemical and biological properties of soil. Agro-ecological determinants of soil that influence cropping systems. Integrated Soil Fertility Management (ISFM) within crop production systems. Evaluation of cropping systems with respect to sustainability indices (e.g. soil quality, water and nutrient productivity, input-output ratios, biodiversity, landscape). Soil health card.
6. Sustainable production and protection in agriculture: Integrated crop management and integrated pest management (IPM) within farming systems. Interactions between the biotic and abiotic factors in agrosystems. Conservation agriculture (including aspects, such as no- and minimum till, rotational and intercropping, precision agriculture, cover crops, green manuring and alternative crops). Organic agriculture and agroforestry. Innovative technological advances in crop production (greenhouse horticulture). Biological and biotechnological approach to control plant pathogens. Protecting crops from losses by integrating plant resistance, cultural practices and biological and chemical control methods. Dr MS Swaminathan Biovillage program in india and china.
7. Sociology of sustainable agriculture: Introduction to the sociology of the environment. Sociological debates on sustainability, development, and livelihoods. Social stratification, gender and diversity. Sociological perspectives on land and conservation issues.
8. Green Technologies: Types, A brief idea about biomas, biogas and biofuel). Role of information and communication technologies for sustainable agriculture, Technology transfer in strict IPR environment.
9. Food production: Current production of food from different sources (global and regional); Issues/ constraints for food production. Methods and strategies for improving crop yield under climate and environment stress. Sustainable diets for the future.
10. Food distribution and accessibility of food resources: The food supply chain (from producers to consumers) - harvesting, transportation, storage, marketing and equitable distribution; Issues for food accessibility and affordability; impact of changing environment and climate on equitable distribution of food.
11. Environment, climate and food security: Food security concept; types of food insecurity; poverty, hunger and malnutrition; Inter-relationship between environment, climate and agricultural (arable agriculture and livestock) and nonagricultural (marine; fresh water; forests) food production; impact on food security.
12. Sustainability assessment of food and agricultural systems following FAO- A brief outline.
13. Food safety: Nutritional security, balanced diet, hunger and human health; Impact of various abiotic environmental pollutants (air, water and soil) and changing climate (heat stress, drought) factors and biotic factors (pests) on quality of food crops.
14. Agricultural planning and food policy in India: Economics and policy of food security; role of institutions

MBOTCCS – 305

Practical (Core)

PLANT PHYSIOLOGY (Credit -1)

1. Determination of water potential of supplied plant samples by Chardakov's method.
2. Isolation of chloroplast and Study of photolysis of water by demonstration of Hill reaction.
3. Effect of high temperature stress on membrane deterioration in terms of lipid peroxidation
4. Effect of respiratory inhibitor on the rate of respiration.
5. Effect of sodium azide on water uptake by plants.
6. Demonstration of a bioassay method for IAA by wheat coleoptile test.
7. Demonstration of cytokinin-induced deferral of senescence by chlorophyll retention test in leaves of different chronological ages.
8. Extraction and estimation of photosynthetic pigments from leaf tissues.

SEED TECHNOLOGY (Credit -1)

1. Proximate analysis of chemical composition of seed; methods of testing viability of seeds;
2. Seed germination and dormancy breaking methods.
3. Seed invigoration and priming treatments.
4. Accelerated ageing and controlled deterioration tests.
5. Vigour testing methods etc.
6. Detection of seed borne fungi, bacteria and viruses, identification of storage fungi.
7. Evaluating seed viability at different RH and temperature levels and packaging materials;

PLANT BIOCHEMISTRY (Credit -1)

1. Extraction and estimation of Catalase
2. Spectrophotometric estimation : Amino acids, DNA , RNA, Protein, phenolics
3. Extraction and estimation of Protein from supplied plant sample.
4. Biochemistry tools: Different Centrifuges, including Ultracentrifuge, Spectrophotometry, Spectroflurometry, Chromatography, 1D SDS-PAGE (Demonstration).

FORESTRY (Credit -1)

1. Measurement of height of a tree.
2. Measurement of diameter and girth.
3. Girth class distribution.
4. Forest survey with GPS
5. Submission of Practical records.

MBOTOPP – 306

Social Outreach Programme

(Credit- 4)

Semester-IV

MBOTCCT – 401

Theory (Core)

Group – A

INSTRUMENTATION **Credit -2 (25 L)**

1. Protein sequencing methods, detection of post-translation modification of proteins; Isolation, separation and analysis of carbohydrate and lipid molecules.
2. DNA sequencing methods, strategies for genome sequencing; Methods for analysis of gene expression at RNA and protein level, Micro array based techniques.
3. Molecular cloning of DNA or RNA fragments in bacterial; expression of recombinant proteins using bacterial and plant vectors; Isolation of specific nucleic acid sequences; generation of genomic and c DNA libraries in plasmid BAC and YAC vectors.
4. RFLP, RAPD and AFLP techniques.
5. Analysis of biomolecules using UV/visible, fluorescence, NMR; Structure determination using X-ray diffraction.
6. Different Radiolabeling techniques, Incorporation of radioisotopes in biological samples, molecular imaging of radioactive material.
7. Microscopy: Principles of light and electron microscopy; Light, Fluorescence, Confocal, SEM, TEM and AFM.
8. Visualization of cells and fine structures: Bright field, fluorescent (confocal and deconvolution) and electron microscopy, Common cell biology techniques: Fractionation, immunoprecipitation, immunolocalization, live cell imaging, flow cytometery; mutant hunts; FRAP, FRET, FLIM, TIRF.

Group – B

BIO STATISTICS **Credit -2 (25 L)**

Introduction—Biological Data analysis steps, Descriptive statistics, Central tendency, Dispersion, Standard error, Statistical Inference, Confidence limits, Tests for nominal variables, Exact binomial test, Power analysis, Chi-square test of goodness-of-fit, Randomization test of goodness-of-fit, Chi-square test of independence, G-test of independence, Fisher's exact test , Randomization test of independence ,Small numbers in chi-square and G-tests, Repeated G-tests of goodness-of-fit, Cochran-Mantel-Haenszel test, Tests for one measurement variable, Student's t-test, Introduction to one-way ANOVA, Kruskal-Wallis test, Paired t-test, Wilcoxon signed-rank test, Sign test, Tests for multiple measurement variables Regression, Linear regression and correlation, Spearman rank correlation, Polynomial regression, Multiple regression, Logistic regression Multiple tests. Multiple comparisons, Meta-analysis.

MBOTMET – 402

Theory (Major Elective)

MAJOR ELECTIVE – 1 **Credit - 4 (50 L)**

MAJOR ELECTIVES:

PALAEOBOTANY AND PALYNOLOGY

1. Physical geology in relation to Palaeobotany: Brief introduction; types of rock, classification of sedimentary rock, tectonic features: fold, fault, taphonomy.
2. Stratigraphy: Outline, Principles of Uniformitarianism and superposition, gaps in the time record, code of stratigraphic nomenclature, Biostratigraphy, Lithostratigraphy, Chronostratigraphy, stratigraphic correlation.
3. Antiquity of life: Major events in the Precambrian- early life forms, Indian records, stromatolites and palaeoecology; Brief account of structural diversity of fossil algae, fungi and bryophytes.
4. Evolutionary theories, evolutionary and environmental changes: Phyletic gradualism, Punctuated equilibrium, pattern of evolutionary change in the plant fossil record; mechanisms driving evolutionary change.
5. Mystery of angiosperm origin: reasons for the late arrival in the fossil record, Pre-Cretaceous angiosperms; early angiosperms and their possible habit; evolution of C_4 and CAM plants; first grasses.
6. Brief concept of mass extinction: evidence in the geological record: plants versus animals; floral changes across the Cretaceous-Palaeocene boundary (K/Pg).
7. Biotic Interactions: Herbivory; Plant animal intereaction and their co evolution in the fossil record.

TAXONOMY OF ANGIOSPERMS AND BIOSYSTEMATICS

1. Systems of Classification - Takhtajan (2009) and APG IV (2016).
2. ICN- Principles, Rules and Recommendations; Type Concept, Conservation and rejection of names, Nomenclature of Cultivated and hybrid plants.
3. Taxonomic literature: Types, definition and examples.
4. Circumscription and Phylogeny of Magnoliidae, Hamamelidae, Caryophyllidae, Rosidae, Asteridae; Alismatidae, Arecidae, Commelinidae and Liliidae [as in Cronquist (1988)].
5. Parasitic, Insectivorous and mycotrophic angiosperms.

MYCOLOGY AND PLANT PATHOLOGY

1. Traditional taxonomic methods & molecular methods of fungal taxonomy
2. Nutrient sensing and uptake in fungi.
3. Aquatic hyphomycetes – Taxonomic diversity, variation in structure and development of conidia and its significance, adaptation and eco-physiology of Ingoldian fungi.
4. Fruit bodies and Ultrastructure of major spore types in fungi, anamorphs and telomorphs.
5. Phyllosphere & phylloplane fungi and rhizosphere and rhizoplane fungi – types, factors, significances.
6. Sex hormones and sexuality in fungi.
7. Yeast biology: Genetic regulation of cell cycle and mating in *Saccharomyces*, secretory route & membrane cycling, killer yeast and killer toxin, Industrial production of alcohol by yeasts. genetic manipulation of brewing yeast. Etiology, treatment and drug resistance of candidiasis.
8. Utilization and metabolism of carbon, nitrogen, vitamins & growth factors in fungal nutrition.
9. Lichenized and lichenicolous fungi – Reproduction and establishment of Mycobiont, nutritional basis of lichen symbiosis.
10. Industrial production of food, antibiotics, organic acids. Role of fungi in agriculture and forestry.
11. Genome organization in fungi.
12. Extra chromosomal and transposable genetic elements in fungi.
13. Principles and general methods of fungal genetic engineering.

MBOTMET – 403

Theory (Major Elective)

MAJOR ELECTIVE – II **Credit - 4 (50 L)**

PALAEOBOTANY AND PALYNOLOGY

1. Palaeofloristics

a) Early Paleozoic and lower Carboniferous flora of India. Permo-carboniferous floral Provinces. Mega-Milo floristic divisions of Indian Gondwana; Glossopteris flora: Distribution in time and space, vegetative and reproductive organography of *Glossopteris* plant.

b) Deccan- intertrappean flora and palaeoecological consideration.

c) Siwalik flora: Dynamics of vegetation and climate in the Himalayas.

d) Pleistocene flora- palaeobotany and palynology with special reference to Kashmir.

2. Plant fossils and climate reconstruction: a) Application in geological investigations, plate tectonics, palaeoenvironment and palaeogeography; NLR, Foliar Physiognomic method, LMA, LAA, CLAMP, stable carbon isotopes and Co-existance approach, determination of pCO2 concentration.

b) Ancient DNA and other fossil plant biomolecules: Extraction, characterization and potential in evolution and climate research; fossil evidence of physiological and developmental mechanism-polar auxin flow. Vegetation dynamics and palaeoclimatic reconstraction through phytolith analysis.

3. Archaeobotany: study of plant economy from Palaeolithic to Historic age.

4. Palaeopalynology:

a) Palaeopalynology of peat, lignite and coal. Artificial classification of sporae-dispersae, role of palaeopalynology and microfossils in oil exploration, identification of isobotanical line, source rocks and palaeoshoreline; kerogen

b) Geological occurrence, structure and palaeoecology of different microfossils such as Acritarchs, Dinoflagellates, Hystrichosphaerids, Radiolaria, Microforaminifera, Ostracods, Silicoflagellates, Diatoms, *Botryococcus*, Coccolithophores.

c) Quaternary palynology in understanding global warming, climate changes, eustatic sea level change, coastal evolution with special reference to Bengal Basin.

5. Neopalynology and their applications: Melittopalynology, Aeropalynology, Archaeopalynology, Forensic Palynology, Copropalynology, Entomopalynology; Natural traps of pollen grains and their importance.

TAXONOMY OF ANGIOSPERMS AND BIOSYSTEMATICS

1. Biosystematics: Definition, aims, methods, categories and relationship with traditional taxonomy.
2. Biodiversity: Definition, Values and ecological services, causes of biodiversity loss; Hotspots and Megadiversity centres.
3. Conservation of Biodiversity : *In situ* and *Ex situ* conservation.
4. BSI, Central National Herbarium and Acharya Jagadish Chandra Bose Indian Botanic Garden.
5. Isolation: Types and significance.
6. Molecular markers: Micromolecular markers (Secondary metabolites) and macromolecular markers from nuclear, chloroplast and mitochondrial genomes; Concept of DNA- Bar coding, Bio Code and Phylo Code.

MYCOLOGY AND PLANT PATHOLOGY

1. Nematophagous fungi – Predatory fungi belonging to Ascomycota & Basidiomycota, endoparasitic nematophagous fungi, nematode fungus interaction (trap formation, adhesion, toxins & infection process), role in biological control.

2. Life cycle patterns, infection process and physiology of biotrophy in rust fungi. Host resistance and gene for gene concept.
3. Foliar and fruit diseases caused by mitosporic fungi. Canker of forest trees. Root & stem rot caused by Basidiomycota.
4. Outline idea of post harvest diseases and their management.
5. Structural and chemical decay of wood by Basidiomycota.
6. Plant – Bacteria interaction: Characteristics of plant pathogenic bacteria, types of diseases, ecology, spread & control. Outline idea about symptoms, disease development & control of bacterial spot and blight (giving emphasis on blight of bean and angular leaf spot of cotton), vascular wilt (giving emphasis on blight wilt of cucurbits & fire blight of pear and apple), soft rot of vegetables, crown gall & scabs.
7. Plant – Virus, viriods interaction: Characteristics of plant viruses, physiology of infected host, transmission, symptoms, disease management (including purification, serology, detection, identification & control). Outline idea of diseases caused by $_{SS}$ RNA, $_{DS}$ RNA & $_{SS}$ DNA viruses.
8. Physiological (photosynthesis, respiration, transpiration, translocation of water & nutrients); and molecular changes in (protein and nucleic acid) in diseased plants.
9. Plant disease resistance: Horizontal and vertical resistance, genetic and biochemical basis of plant disease resistance; systemic acquired resistance (SAR) and induced resistance, classes and functional analysis of plant defense genes. Hypersensitive reactions - the mechanism of elicitor-receptor concept.
10. Role of plant breeding, biotechnology & tissue culture in plant pathology

MBOTMES - 404

Practical (Major Elective)

(Credit -4)

PALAEOBOTANY AND PALYNOLOGY

1. Physical Geology: types of rocks, Tectonic features: Fold, Fault, environmental features of deposition: BIF, Varved sediments. Geological maps showing sedimentary basins of India.
2. Modes of preservation.
3. Pre-Cambrian, Palaeo-Meso-Cenophytic plants: Stromatolites, Oncolith, Thallophytes to angiosperms (Gondwana, Euramarian, Cathaysian); Microfossils- Carboniferous to Quaternary, fossil algae, fungi, acritarch, dinoflagellates, *Botryococcus*, hystrichosphaerid, Fossil salt glands *Heliospermopsis*, phytoliths.
4. Anatomical study of fossils through ages (peel section) Carboniferous- Quaternary (Northern and Southern Hemisphere).
5. Thin section method- thin section of wood.
6. Peel- technique- Coal ball, Coalified compression.
7. Palynological techniques- Acetolysis methods, study of living spores and pollen with different apertural types and ornamentation pattern.
8. Study of aerospora using natural trap; pollen analysis of cattle dung and insect gut content.
9. Maceration techniques- i. Peat ii. Lignite iii. Coal iv. Shale v. Clay vi. Sandstone vii. Heavy liquid separation- study of fossil spores, pollens, other microfossils of Palaeozoic, Mesozoic, Cenozoic age. Camera lucida drawing, measurement and tally mark counting of biota, palynogram, histogram.
10. Transfer technique; preparation of cuticle for study of venetion pattern and epidermal features, pCO2 concentration and epiphyllous fungi.

11. Field excursion for familiarization with and study of fossil remains of areas outside the state, and in the local areas, and training in collection and preservation methodologies.
12. Project work.

TAXONOMY OF ANGIOSPERMS AND BIOSYSTEMATICS

1. Application of ICN rules in solving nomenclatural problem.
2. Working out of different angiospermic plants (dry specimens), their identifications upto species using literature.
3. Preparation of taxonomic keys, illustrations and phytography applying the pattern followed in floras.
4. Field study of species selected from the substances mentioned in the theory syllabus (precise note on exomorphic features, associated species, life-forms, observation relevant to its habit of reproduction).
5. Field excursion for familiarization with and study of vegetation type(s) and flora(s) of areas outside the state, and in the local areas.
6. Submission of herbarium specimens, field note book and laboratory records.

MYCOLOGY AND PLANT PATHOLOGY

1. Study of hyphal types in fungal sporocarps.
2. Demonstration of Koch's postulate for a fungal pathogen.
3. Study of airborne fungi with volumetric spore trap.
4. Isolation and identification of rhizosphere soil fungi.
5. Isolation and identification of AM Mycorrhiza from root.
6. Study of mycoflora from vermicompost.
7. Study of endosymbiontic fungi.
8. Isolation and identification of seed mycoflora and estimation of protein of diseased and disease free seeds.
9. Estimation of total phenols in diseased and healthy host tissue.
10. Extraction and assay of peroxidase activity in plants following infection
11. Determination of role of pectic enzymes produced by pathogens in host tissue maceration
12. Determination of role of cellulase enzymes produced by pathogens in host tissue decay
13. Laboratory testing of fungicides: a) standard procedure for preparation of spore suspension b) standard procedure for preparation of stock solution of test chemicals c) standard procedure for fungicidal bioassay using spore germination technique.
14. Demonstration of GEL electrophoretic techniques.

MBOTACT – 405

Review / Project presentation on Major Elective paper: (Credit: 4)

MBOTACT – 406

Add-on Course (Credit: 4) 50 L.

Environmental protection and management:

1. Ecosystems of the world and distribution of Flora and Fauna: Major terrestrial (forest ecosystem types), aquatic ecosystems (inland and marine ecosystem; types, crisis and conservation of wetlands) and Biomes of the world. floristic and zoogeographical Realms; Principles of dynamic phytogeography.

2. Natural resource Ecology: Classification of resource (Renewable and non-renewable resources); Types, importance, threats and conservation of biodiversity; Resource management.

3. Human Population and Environment: Population growth; environment and human health; women and child welfare.

4. Pollution Ecology: Concept of air, water, solid wastes, soil, noise and radiation pollution and their control; Climate change and global warming, Acid rain and Ozone Depletion; Lessons from Industrial accidents and future policy.

5. Environmental toxicology: Toxic chemicals and factors affecting toxicity; Sources (Routes and rate of administration); Effects and mechanism of toxicant action; Metal toxicity at cellular level; Synergism and Antagonism; Translocation and Bio-accumulation of toxicants; Biotransformation; toxicity tests and management of toxicants.

6. Environmental Monitoring and Impact Assessment: Biological monitoring programme; Bioindicators and Environmental monitoring; Environmental impact assessment; Environmental management.

7. Environmental laws and Regulations: Objectives of environmental management; ISO14001 certification; The Indian constitutional provisions regarding the environments; Environmental legislation in India: (The environment (protection) Act of 1996; The Air (prevention and control of Pollution) Act of 1981; Water (prevention and control of pollution) Act of 1980; The forest Conservation Act of 1980; Wildlife Protection act of 1972; The national Green Tribunal.

8. Eco-technology: Environmental biotechnology and Biotechnology firms; Biotech drugs; Traditional knowledge; Bio-safety; Ecotechnology for Eco Remediation.

8. Global sustainability: Ecological –Societal gaps; Brundtland Report; Environmental Ethics; Dual capitalism; Paradox in technological development; Restoration ecology; Green economy and green jobs.

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