West Bengal State University

Barasat, Kolkata-700 126, INDIA

2-Yr M.Sc. in Botany 2026 as per NEP 2020

Program Specific Output (PSO): Botany as a discipline through the past decades has been transforming itself rapidly through interdisciplinary and technological inputs, which have brought about a paradigm shift in our knowledge and understanding of the diversity of plant and microbe life as well as their interaction. New niche areas in plant developmental biology, molecular ecology, statistical genetics, transcriptomics of stress interactions of plants, next gen sequencing, predictive models of decision support systems combining large data as well as artificial intelligence and population genetics studies in preventing disease losses, structural modelling and phylogeny constructions through bioinformatics have been created due to cutting edge research in these fields which are now all a part of the Plant sciences. The M.Sc. program in Botany endeavours to expose the student to these changes in order to bridge the traditional boundaries of the subject and excite him/her not only to pursue further higher studies but also to prepare him/her for the future workplace. These concepts and skills are developed through core and elective courses, many of which cover current, relevant topics drawn from review papers, students' projects, and, in part, the research programs undertaken by the department.

The M.Sc. program links current research findings and developments in the field and allied areas with the subject specialisations in a holistic way. Some examples would be as follows: The students, in general, are familiarised with the diversity of life in natural habitats, which are then identified and characterised in the laboratory using both traditional and molecular methods, employing some of the latest techniques, and, where feasible, partial genomes are sequenced and phylogenies constructed. This allows students to be exposed to the full gamut of processes they would face in a real work environment. Exposure to biochemical and molecular pathways in plants through real-life problems of ecological bioremediation, etc., is emphasised. The USP of the program is that the endeavour is always to prepare and expose the student to translational research as far as applicable for the various streams in Botany, if not fully through the practical syllabi, then at least through the theoretical syllabi.

General instructions:

1. West Bengal State University, Barasat shall provide instructions leading towards course requirements for admission into the M.Sc. degree in Botany through its regulations as amended from time to time. A candidate who has passed the three-year B.Sc. examination with Honours (Major) in Botany or Minor in Botany will be eligible for admission to this course on the basis of merit.

2. The duration of the course shall be 2 years for 3-year (6-semester) undergraduates for the M.Sc. degree in Botany, and the examination for the M.Sc. degree in Botany shall be held in four semesters, with a total of 1150 marks. The duration of the semester shall be as follows:

For 2-year M.Sc.:

1st Semester July -Mid-January

2nd Semester Mid-January - June

3rd Semester July - December

4th Semester January – June

3. The course shall comprise a total credit of 88 (eighty-eight), for 2-Yr M.Sc., evenly distributed over the four semesters. The courses shall be grouped into Departmental core courses (COR) and Electives comprising DSE, SEC & AEC, and will carry credits according to the number of theoretical classes required, study hours, and laboratory hours as applicable.

Choice of electives:

DSE- Departmental courses in Semester IV (2-Yr M.Sc.) are the Departmental Specific Electives courses. One course each from each DSE has to be taken by the student. Only the following combinations will be permitted.

Course combinations offered for DSE papers		
Course Codes	**BOT2PDSE01T**	**BOT2PDSE02T**
Combination 1	# Plant Virology & Molecular Mycology	# Molecular Plant Pathology
Combination 2	# Molecular Genetics & Advanced Cell Biology	# Applied Plant Breeding &Plant Tissue Culture
Combination 3	# Advanced Plant Physiology & Biochemistry	# Plant Molecular Biology
Combination 4	# Angiosperm Taxonomy & Biosystematics	# Plant Ecology and Environmental Biology-II

SEC: One course in Semester-III (2-Yr M.Sc.) among the choices given in the syllabus

AEC: Course to be conducted centrally for all departments in Semester I (2-Yr M.Sc.)

Assessment modalities:

Theory

All the Departmental courses (both COR, AEC, SEC, and DSEs) will have a Mid-Term Evaluation/Examination worth 10 marks and an End-Term examination worth 40 marks.

Laboratory courses & Project

Laboratory Courses will have continuous evaluation for 80% of the allotted marks, and for 20% marks, an examination will be held in the presence of external expert/(s), which may include all, one or some of the following modes of assessment: *viva-voce*, presentation, submissions, field note books, herbarium sheets, etc., as required.

Semester-wise Courses, Credits and Marks distribution:

2-Yr M.Sc. in Botany

Semester	Courses	Codes	Credits	Marks	Total
I	Integrated Life Sciences (ILS) DS-1	BOT2PCOR01T	4	50	Credits 22 Marks 300
	Plant Developmental Biology & Anatomy (DS-2)	BOT2PCOR02T	4	50	
	Research practices and regulatory affairs in Plant Sciences (DS-3)	BOT2PCOR03T	4	50	
	Bioinformatics (DS-4)	BOT2PCOR04M	4	50	
	AEC	BOT2PAEC01M	2	50	
	Indian Knowledge Systems in Plant Sciences	BOT2PCOR05M	4	50	
II	Plant Systematics (DS-6)	BOT2PCOR06T	4	50	Credits 20 Marks 250
	Plant Ecology and Environmental Biology-I (DS-7)	BOT2PCOR07T	4	50	
	Advanced & Translational Plant Biology (DS-8)	BOT2PCOR08T	4	50	
	Industrial & Environmental Microbiology (DS-9)	BOT2PCOR09T	4	50	
	Laboratory Course (DS-10)	BOT2PCOR10P	4	50	
III	Diversity of Microbes (Bacteria, Viruses, Fungi, Oomycetes), Plant Pathology & Crop Protection (DS-11)	BOT2PCOR11T	4	50	Credit 22 Marks 300
	Diversity of Plant Life (Algae, Bryophytes, Pteridophytes, Gymnosperms, Palaeobotany & Palynology) (DS-12)	BOT2PCOR12T	4	50	
	Molecular Genetics and Plant Breeding (DS-13)	BOT2PCOR13T	4	50	
	Plant Physiology & Biochemistry (DS-14)	BOT2PCOR14T	4	50	
	SEC	BOT2PSEC01M	2	50	
	Laboratory Course (DS-15)	BOT2PCOR15P	4	50	
IV	**Department Specific Electives (DSE)** # Plant Virology & Molecular Mycology, or # Molecular Genetics & Advanced Cell Biology, or # Advanced Plant Physiology & Biochemistry, or	BOT2PDSE01T	4	50	Credit 24 Marks 300

	# Angiosperm Taxonomy & Biosystematics				
	Department Specific Electives (DSE) # Molecular Plant Pathology, or # Applied Plant Breeding & Plant Tissue Culture, or # Plant Molecular Biology, or # Plant Ecology and Environmental Biology-II	BOT2PDSE02T	4	50	
	*Dissertation-I (based on the DSE combination chosen)	BOT2PDSE03M	4	50	
	*Dissertation-II (based on the DSE combination chosen)	BOT2PDSE04M	4	50	
	**Presentation (based on the DSE combination chosen)	BOT2PDSE05M	4	50	
	Laboratory Course	BOT2PDSE06P	4	50	

* Students can opt in consultation with the supervisor to do 2 separate / allied dissertation or one dissertation

** Presentation (BOT2PDSE05M) will combine with Both BOT2PDSE03M & BOT2PDSE04M

2-Year M.Sc. in Botany
Semester-I

BOT2PCOR01T

INTEGRATED LIFE SCIENCES (ILS) (50 marks)

Course outcome: This integrated life sciences course will familiarise students with the fundamentals of the life sciences. It will introduce students to common areas of the life sciences, such as cell structure and function, cell signalling, cancer biology, immunology, development, molecular biology and other analytical techniques used in biology, and basic biostatistics. It is a very preliminary course that augments students' vision and acceptance of more complex courses built on this foundation. This course will greatly assist students taking other courses in the latter part of the semester.

Course details:

Membrane structure and function: Structure of model membrane, lipid bilayer and membrane protein diffusion, osmosis, ion channels, active transport, ion pumps, mechanism of sorting and regulation of intracellular transport, and electrical properties of membranes.

Cellular communication: Regulation of hematopoiesis, general principles of cell communication, cell adhesion and roles of different adhesion molecules, gap junctions, extracellular matrix, integrins, neurotransmission and its regulation.

Cancer*:* Genetic rearrangements in progenitor cells; oncogenes and tumour suppressor genes; cancer and the cell cycle; virus-induced cancer; metastasis; interactions between cancer cells and normal cells; apoptosis; therapeutic interventions for uncontrolled cell growth.

Immunology*:* Cells and molecules involved in innate and adaptive immunity, antigens, antigenicity and immunogenicity. Structure and function of antibody. MHC molecules, antigen processing and presentation, activation and differentiation of B and T cells. Autoimmunity; immune responses during bacterial (tuberculosis), parasitic (malaria), and viral (HIV) infections; congenital and acquired immune deficiencies; vaccines.

Basic concepts of animal cell development: Potency, commitment, specification, induction, competence, determination and differentiation; morphogenetic gradients; cell fate and cell lineages; stem cells; genomic equivalence and the cytoplasmic determinants; imprinting; mutants and transgenics in analysis of development.

Morphogenesis and organogenesis in Eukaryotes: Cell aggregation and differentiation in *Dictyostelium*; axes and pattern formation in *Drosophila*, amphibia and chick. Organogenesis and regeneration of different organs in vertebrates. Differentiation of neurons, post embryonic development-larval formation, metamorphosis; environmental regulation of normal development; sex determination.

Methods in Biology: Molecular biology and recombinant DNA methods: Isolation and purification of RNA, DNA (genomic and plasmid) and proteins; analysis of RNA, DNA and proteins by one and two dimensional gel electrophoresis, isoelectric focusing gels; molecular cloning of DNA or RNA fragments in bacterial and eukaryotic systems; expression of recombinant proteins using bacterial, animal and plant vectors; regeneration of genomic and

cDNA libraries in plasmid, phage, cosmid, BAC and YAC vectors; protein sequencing methods, detection of post-translation modification of proteins; DNA sequencing methods, strategies for genome sequencing,

Histochemical and immuno-techniques: Antibody generation, detection of molecules using ELISA, RIA, western blot, immunoprecipitation, flow cytometry, and immunofluorescence microscopy, detection of molecules in living cells, *in situ* localisation by techniques such as FISH and GISH. Brief description of Plant and Animal cell culture and cryopreservation technique for artificial seeds.

Basic statistics: Populations and sample, Experimental design, Data analysis, graphs, average, measure of central tendency, dispersal, probability, co-efficient distributions (Chi-square, Binomial, Poisson, and Normal), Tests of significance- t-test, z-test, F-test, U-test and others, Regression and correlation, Analysis of variance, Errors. Various statistical software in biology and their uses.

Suggested Readings:

1. Voet, D., & Voet, J. G. (2011). Biochemistry. New York: Wiley.
2. Kalidas, C., & Sangaranarayanan, M. V. (2023). Biophysical chemistry: Techniques and applications. Singapore: Springer.
3. Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P. (2015). Molecular biology of the cell (6th ed.). New York: Garland Science.
4. Wardhan, R., & Mudgal, P. (2018). Textbook of membrane biology. Singapore: Springer.
5. Lodish, H., Berk, A., Kaiser, C. A., Krieger, M., Scott, M. P., Bretscher, A., … Darnell, J. (2021). Molecular cell biology (9th ed.). New York: Macmillan.
6. Shehzad, A. (2025). Cell signaling: Interplay, mechanisms, and therapeutic implications. Boca Raton: CRC Press.
7. Taiz, L., Zeiger, E., Møller, I. M., & Murphy, A. (2015). Plant physiology and development (6th ed.). Sunderland, MA: Sinauer Associates.
8. Pua, E. C., & Davey, M. R. (2010). Plant developmental biology – Biotechnological perspectives. Berlin: Springer.
9. Sambrook, J., & Russell, D. W. (2001). Molecular cloning: A laboratory manual (3rd ed.). Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.
10. Debnath, M., & Swati. (2024). A handbook on techniques of molecular biology. New Delhi: Orange Books.
11. Harlow, E., & Lane, D. (1988). Antibodies: A laboratory manual. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.
12. Mondal, S. K. (2025). Manual of histological techniques (3rd ed.). New Delhi: Jaypee Brothers Medical Publishers.

BOT2PCOR02T

PLANT DEVELOPMENTAL BIOLOGY AND ANATOMY (50 marks)

Course outcome: This is an emerging research area in plant science. Although the subject is still young, we intend to expose our students to state-of-the-art knowledge in this specific area. Plant developmental studies that identify genes associated with developmental events are mostly conducted in model species, and this area of study is largely based on mutant generation. We

expect the students to admire this fascinating area, which is highly relevant to the current scientific landscape, and to benefit from this study.

Course details:

Seed germination and seedling growth: Metabolism of nucleic acids, proteins and mobilisation of food reserves; tropisms; use of mutants in understanding seedling development; orthodox and recalcitrant seeds, types of seed dormancy, breaking of dormancy, biochemical changes during dormancy.

Shoot development: Organisation of the shoot apical meristem (SAM); Genes controlling SAM development; Molecular control of cell division; Control of genes on tissue differentiation;

Leaf growth and differentiation: Genes controlling leaf polarity development; Molecular control of leaf shape, simple and compound leaf development, with help of established mutants; Control of genes in leaf surface component development like hairs, trichomes, stomata.

Root development: Organisation of root apical meristem (RAM); Molecular control of cell fates and lineages; Genes involving vascular tissue differentiation, lateral roots, root hairs; Oxidative pathways related to RAM development.

Reproduction: Transition of vegetative shoot apex to flowering; Molecular control of inflorescence, floral meristem and flower development, ABCE model; Homeotic mutants in *Arabidopsis* and *Antirrhinum*; Established mutants and transgenics associated with floral development.

Male gametophyte: Molecular control of tapetum, microsporogenesis, pollen development; Male sterility.

Female gametophyte: Ovule development; Genes controlling megasporogenesis, and embryo sac development,

Pollination, pollen-pistil interaction and fertilization: Breeding systems; Structure of the pistil; Pollen-stigma interactions, Molecular basis of sporophytic and gametophytic self-incompatibility; Double fertilization (structural and molecular aspects).

Seed and fruit development: Endosperm development during early, maturation and desiccation stages, embryogenesis, cell lineages during late embryo development; Hybrid seed production and apomixis in its current scenario; Dynamics of fruit growth, biochemistry and molecular basis of fruit ripening and maturation; Roles of ethylene in fruit ripening with established transgenics and their commercialisation.

Latent life-dormancy: Importance and type of dormancy; seed dormancy; Overcoming seed dormancy, bud dormancy with their molecular basis, viviparous seeds.

Senescence and programmed cell death (PCD): Basic concepts, types of programmed cell death, differences among apoptosis, autophagy, necrosis, and PCD in plants; Role of PCD in plant structure and development; Metabolic changes associated with senescence and its regulation; Molecular basis of senescence, role of growth hormones and environmental factors.

Suggested Readings:

1. Introduction to Plant Physiology: William G. Hopkins and Norman P.A. Huner. (Fourth Edition) 2008. John Wiley& Sons, Inc.

2. Biochemistry and Molecular Biology of Plants, 2nd Edition

Bob B. Buchanan (Editor), Wilhelm Gruissem (Editor), Russell L. Jones (Editor)

ISBN: 978-0-470-71421-8. July 2015.

3. Lehninger Principles of Biochemistry: David L. Nelson and Michael M. Cox.(Fifth edition) 2009. W. H. Freeman publication.
4. Biochemistry: Jeremy M. Berg, John L. Tymoczko, Lubert Stryer. (Fifth edition). 2002. W.H. Freeman publication.
5. Plant Physiology and Development:
By Lincoln Taiz, Ian Max Møller, Angus S. Murphy, Eduardo Zeiger, 2023, Sinauer Associates (7th Edition)

Related review articles in the following Journals:

_ Annual Review of Plant Biology
_ Critical Reviews in Plant Science
_ Current Opinion in Plant Biology
_ Trends in Plant Science
_ Plant Physiology, Plant Cell

BOT2PCOR03T
RESEARCH PRACTICES AND REGULATORY AFFAIRS IN PLANT SCIENCES (50 Marks)

Course outcome: This is a very contemporary area, absolutely essential for research in plant sciences. We intend to expose our students to state-of-the-art knowledge in this specific area. We expect this knowledge of extant relevant research practices and biosafety guidelines and regulations currently in place in India to well equip students to carry on their further academic/research careers in the current scientific landscape and to benefit from this study.

Course details:

Biosafety and Laboratory Practices:

Biosafety Definition: Prudent biosafety practices in laboratory environment/institution; Discipline, safety, and care; Biological hazards and levels of biosafety; Biosafety regulations and Institutional Biosafety Committee.

IPR:

Introduction and meaning of Intellectual Property Rights; Preliminary awareness about TRIPS and WTO; Kinds of Intellectual Property Rights: Copyright, Patent, Trade Mark, Trade Secret, Geographical Indication, Plant Varieties, and Traditional Knowledge; Patent rights and copyright rights: Meaning of Patent, Types, Inventions which are not patentable, Registration Procedure, Infringement, Remedies & Penalties; Examples of biological patents.

Research Paper writing:

Research paper types; How to write a research paper; Journal publishing models, Publishing ethics and metrics: Open access, preprint, predatory journals; Research metrics; Publication misconduct and ethics; Plagiarism check and UGC penalties.

Research Grant Writing:

Proforma to be taken from public-funded extramural funding agencies, viz., ICMR, DBT, CSIR, DST, ICAR, etc.

Literature Search and Databases:

Search using scientific search engines; Indexing and citation databases.

Research Institutes in Life Sciences: Brief overview (location and mandate) of national research institutes and international institutes located in India, allied to Plant Sciences.

Suggested Readings:

1. Hofmann, A., & Clokie, S. (Eds.). (2018). Wilson and Walker's principles and techniques of biochemistry and molecular biology (8th ed.). Cambridge University Press.

BOT2PCOR04M
BIOINFORMATICS (50 Marks)

Course outcome: This is another very contemporary area, absolutely essential for research in plant sciences. We intend to expose our students to state-of-the-art knowledge in this specific interdisciplinary area. Without exposure to the latest bioinformatics knowledge and its current applications in analysing research results, students will be academically disadvantaged. We expect this course and its relevant hands-on training will definitely help our students carry on with their future academic/research careers in the current scientific landscape.

Course details:

Introduction to Bioinformatics

Introduction; Branches of Bioinformatics; Aim, Scope, and Research Areas of Bioinformatics.

Databases in Bioinformatics

Introduction; Biological Databases; Classification Format of Biological Databases; Biological Database Retrieval System.

Biological Sequence Databases

National Center for Biotechnology Information (NCBI): Tools and Databases of NCBI; Database Retrieval Tool; Sequence Submission to NCBI; Basic Local Alignment Search Tool (BLAST); Nucleotide Database, Protein Database, Gene Expression Database; EMBL Nucleotide Sequence Database (EMBL-Bank): Introduction, Sequence Retrieval, Sequence Submission to EMBL; Sequence Analysis Tools; DNA Data Bank of Japan (DDBJ): Introduction, Resources at DDBJ, Data Submission at DDBJ; Protein Information Resource (PIR): About PIR, Resources of PIR, Databases of PIR, Data Retrieval in PIR; Swiss-Prot: Introduction and Salient Features.

Sequence Alignments

Introduction; Concept of Alignment; Multiple Sequence Alignment (MSA), MSA by CLUSTALW; Scoring Matrices, Percent Accepted Mutation (PAM); Blocks of Amino Acid Substitution Matrix (BLOSUM).

Molecular Phylogeny

Methods of Phylogeny; Software for Phylogenetic Analyses; Consistency of Molecular Phylogenetic Prediction.

Applications of Bioinformatics

Structural Bioinformatics in Drug Discovery; Microbial genome applications; Crop Whole Genome in agricultural improvement.

Suggested Readings

1. Ghosh Z. and Bibekanand M. (2008) Bioinformatics: Principles and Applications. Oxford University Press.
2. Pevsner J. (2009) Bioinformatics and Functional Genomics. II Edition. Wiley-Blackwell.
3. Campbell A. M., Heyer L. J. (2006). Discovering Genomics, Proteomics, and Bioinformatics. II Edition. Benjamin Cummings.
4. Mount, D. W. (2004). Bioinformatics: Sequence and genome analysis (2nd ed.). Cold Spring Harbor Laboratory Press.
5. Pevsner, J. (2015). Bioinformatics and functional genomics (3rd ed.). Wiley-Blackwell.

6. Rastogi, S. C. (2009). Bioinformatics: Methods and applications: Genomics, proteomics and drug discovery (4th ed.). PHI Learning.
7. Xiong, J. (2006). Essential bioinformatics. Cambridge University Press.

BOT2PAEC01M

AEC: UNDERSTANDING AND PRESENTING SCIENTIFIC LITERATURE (50 marks)

Course outcome: On completion of this course, the students will be (i) familiar with journals in plant sciences and related disciplines, (ii) Bibliographic and literature search using abstract (Web of Science, etc) and full-text database platforms (Scopus, Science Direct), (iii) Bibliographic formatting using proprietary software like EndNote or other open-source ones. (iv) ability to read review/research papers, understand, and discuss them (v) able to improve presentation skills using ICT tools.

Course details: Awareness about scientific journals and publishers, Open access, Citation indexes, peer-reviewed journals, and names of sub-discipline-specific journals. Tools for literature searches- abstract and full text, awareness about different databases, Citation styles, formatting tools for references-EndNote, Open access sources (Mendeley/Zotero), MS Word-References and review modes. Current review topics of relevance to be selected for discussion by students moderated by the teacher. Introduction to PowerPoint presentations, Tips and guidance for better presentation of scientific topics.

BOT2PCOR05M

Indian Knowledge Systems in Plant Sciences (50 marks)

Course Learning Outcomes

Upon successful completion of this course, students will be able to:

Trace the evolution of plant science in India, from early references in Vedic and Ayurvedic literature to the development of modern botanical research.

Understand plant classification and nomenclature; the scope and significance of ethnobotanical knowledge, particularly in the cultural, plant wealth, and ecological contexts of Bengal and eastern India; and appreciate ecological ideas embedded in traditional Indian thought within Indian Knowledge Systems, including Sanskrit texts and regional folk taxonomies, and their relevance to contemporary approaches.

Course details:

Early Foundations of Plant Knowledge in India: Plant knowledge in the Vedic and early philosophical texts, botanical ideas in classical ayurvedic literature, early observations on plant growth, health and cultivation in traditional texts, conceptual understanding of plant life in classical Indian thought, agricultural practices in classical Indian thought.

Classical Textual Traditions in Indian Plant Science: Botanical knowledge in the Charaka Samhita and Sushruta Samhita; Parashara's Vrikshayurveda and early agricultural–botanical knowledge; the Nighantu tradition and early documentation of medicinal plants; the concept of Ayurveda and its current status; the role of Sanskrit literature in preserving plant knowledge.

Emergence of Modern Botanical Science in India: Early European botanical explorations in India (16th–18th centuries); contributions of Portuguese, Dutch, Danish, and British naturalists;

development of botanical exploration and plant documentation; early botanical writings on Indian flora.

Institutional Development of Botany in India: Establishment of botanical gardens and herbaria in colonial India, growth of systematic botany during the 19th and early 20th centuries, role of botanical institutions and surveys, development of botanical research in independent India.

Plant Classification and Nomenclature in Traditional Knowledge Systems: Traditional plant classification in Sanskrit texts, folk and indigenous plant classification practices, Sanskrit plant nomenclature and regional plant names, linking vernacular plant names with modern scientific binomials.

Ethnobotany and Cultural Plant Traditions of Bengal: Scope and approaches of ethnobotany, plants in rituals, festivals and folk traditions of Bengal, sacred plants and their cultural symbolism, ethnobotanical knowledge among rural and tribal communities of eastern India.

Traditional Ecological Knowledge and Conservation: Ecological perspectives in Indian philosophical traditions; sacred groves and community-protected landscapes; indigenous forest management and plant conservation practices; the role of traditional ecological knowledge in biodiversity conservation.

Indigenous Agriculture and Integration with Modern Plant Science: Traditional crop diversity and indigenous seed conservation, agroecological practices: mixed cropping, crop rotation and organic soil management, traditional irrigation and plant resource management systems, integration of traditional plant knowledge in modern botanical research and conservation.

Suggested Readings

1. Jain, S.K. (2016). *Ethnobotany in India*. Deep Publications, New Delhi.
2. Jain, S.K. (1991). *Dictionary of Indian Folk Medicine and Ethnobotany*. Deep Publications, New Delhi.
3. Cotton, C.M. (1996). *Ethnobotany: Principles and Applications*. John Wiley and Sons, Chichester.
4. Schultes, R.E., and Reis, S.V. (1995). *Ethnobotany: Evolution of a Discipline*. Chapman and Hall, London.
5. Sadhale, N. (1996). *Surapala's Vrikshayurveda (The Science of Plant Life by Surapala)*. Asian Agri-History Foundation, Secunderabad.
6. Dash, B. (2006). *Charaka Samhita*. Chowkhamba Sanskrit Series Office, Varanasi.
7. Desmond, R. (1992). *The European Discovery of the Indian Flora*. Oxford University Press, Oxford.
8. Prain, D. (1903; reprint editions). *Bengal Plants*. Botanical Survey of India, Kolkata.
9. Gadgil, M., and Guha, R. (1992). *This Fissured Land: An Ecological History of India*. Oxford University Press, New Delhi.
10. Ramakrishnan, P.S. (2001). *Ecology and Sustainable Development*. National Book Trust, New Delhi.
11. Sacred Groves of West Bengal. West Bengal Biodiversity Board, Government of West Bengal, Kolkata.
12. Relevant Scientific articles

Semester -II

BOT2PCOR06T

PLANT SYSTEMATICS **(50 marks)**

Course outcome: The course will equip the student to

(i) Understand the origin and diversification of flowering plants.

(ii) Familiarity with the advanced aspects of the principles of taxonomy (identification, nomenclature, classification of flowering plants), evolution (speciation, reproductive biology, adaptation, convergence, biogeography), and phylogenetics (phenetics, cladistics, morphology and molecules).

(iii) Do systematic survey of plant families, understand the evolutionary processes and patterns in the major families and develop expertise on the representative families and local flora.

Course details:

Taxonomic evidence and concepts of characters: Palynology, phytochemistry, ultrastructure and molecular characters in relation to taxonomy.

Botanical Nomenclature: ICBN, changes, additions, and alterations of the latest codes; rank of taxa and the names of taxa; priority; effective and valid publication; citations of authors; changes and rejections of names.

Major systems of angiosperm classification: Outline of classification of Cronquist (1988), Takhtajan (1997) and Thorne (2007) up to sub-classes/ 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.

A general survey of the following orders of angiosperms (*Sensu* Cronquest, 1988) with salient features, inter relationships, evolutionary trends and economic importance: Magnoliales, Caryophyllales, Nepenthales, Podostemales, Asterales, Orchidales, and Liliales.

Biosystematics: Definition, methods, categories, relationship and differences with classical taxonomy.

Numerical taxonomy: Principles, methods, merits and demerits.

Phylogenetic taxonomy: Nature of phylogeny; heterobathmy, polarity and morphocline; anagenesis and cladogenesis; plesiomorphy, apomorphy, synapomorphy, symplysiomorphy; parallelism and convergence; monophyly, paraphyly, polyphyly; importance of homology, polarizing characters of homology, homoplasy and problems of homoplasy; polygram and cladogram, Cladistic system of classification of angiosperms, basic principles.

Species/genes/family and other categories: Cladistics and adaptive radiation, microevolution: theory and concepts; species and speciation; Phylogenetic systematics; Macroevolution inferring phylogenies.

Molecular Systematics: Plant genomes, nuclear, mitochondrial, chloroplast; Molecular markers; generating molecular data; restriction site mapping; gene sequencing; analysis of molecular data; alignment of sequences; methods of phylogeny reconstruction.

Suggested Readings:

1. Plant Biosystematics: Grant W.F., Academic Press, London.
2. New Concepts in Flowering Plants Taxonomy: Harrison, H.J., Hieman Educational Books, Ltd. London.

3. Singh, G. (2012). Plant Systematics: Theory and Practice. Oxford & IBH Pvt. Ltd., New Delhi. 3rd edition.
4. Jeffrey, C. (1982). An Introduction to Plant Taxonomy. Cambridge University Press, Cambridge.
5. Judd, W.S., Campbell, C.S., Kellogg, E.A., Stevens, P.F. (2002). Plant Systematics: A Phylogenetic Approach. Sinauer Associates Inc., U.S.A. 2nd edition.
6. Maheshwari, J.K. (1963). Flora of Delhi. CSIR, New Delhi.
7. Radford, A.E. (1986). Fundamentals of Plant Systematics. Harper and Row, New York.

BOT2PCOR07T

PLANT ECOLOGY AND ENVIRONMENTAL BIOLOGY-I (50 marks)

Course outcome: This course familiarises the students with issues of plant ecology and the environment. The environmental interactions of the plant system are being taught in this course. The interspecies competition and resilience study, biodiversity assessment, and ecology-based conservation themes are the major areas of study that will introduce students to state-of-the-art knowledge of ecology and the environment. Students will really benefit from learning about this very contemporary branch of botany.

Course details:

Plant Ecology:

The Environment: Physical environment, biotic environment, biotic and abiotic interactions.

Habitat and Niche: Concept of habitat and niche; Niche width and overlap, fundamental and realized niche; Ecological niches and pattern of resource use; Resource partitioning.

Species interaction: Types of interactions, inter-specific competition demonstrated by Lotka - Volterra model, Tilman's model; Competitive exclusion theory, Gause's experiment; Intraspecific scramble and contest competition model; Mutualism and commensalisms; Prey-predator interactions study through models; Grime's theory of C-S-R triangle in plant life cycle; Character displacement.

Population Ecology: Characteristics of a population, population dispersal patterns, survivorship curves; Logistic and exponential growth, growth curves; Population dynamics, population regulation, carrying capacity, life history strategies (r and k selection); Fertility rate and age structure, concept of meta-population demes and dispersal; Capture and Re-Capture method.

Ecosystem: Structure, function, primary production and decomposition, energy flow and mineral cycling (CNP), biogeochemical cycles; Resilience of ecosystem, ecosystem management; biosphere, biomes and impact of climate on biomes; Structure and function of some Indian ecosystems; terrestrial (forest, grassland) and aquatic (fresh water, marine, estuarine).

Applied ecology: Environmental stresses and their management; Global climatic pattern and variation over time; Global climatic changes and global warming, atmospheric ozone, acid and nitrogen deposition, sea level rise, environmental pollutants in air, water and soil ; Fate of excessive use of fertilizers, pesticides in agriculture; Waste disposal from industry causing environmental pollution;; Bioremediation, Natural farming, Pollution control by Central Pollution Control Board as environmental policies and regulation.

Environmental Conservation:

Biodiversity and conservation: Assessment, monitoring and documentation, Conservation and biodiversity management approaches by IUCN threatened categories and their criteria some major Indian species under IUCN threatened categories; Keystone, Flagship, Umbrella, Indicator species; Biodiversity hotspots; Abundance models; Biodiversity indices: Berger-Parker, Shannon-Weiner, Simpson's, Brillouin's; Alpha , Beta and Gamma diversity; Biodiversity act of

India and related international conventions; Protected area under conservation in India (Biosphere Reserve, Sanctuaries, National Parks); OECM concept of conservation and its global criteria.

Restoration of ecosystems: Degraded ecosystem restoration and rehabilitation; Concepts of Ecological Restoration.

Community ecology: Nature of communities; Community structure and attributes; Levels of species diversity and their measurement; Edges and Ecotones.

Ecological succession: Types; mechanisms; Changes involved in succession; Concept of climax.

Biogeography: Major terrestrial, and aquatic biomes; Theory of island biogeography; Biogeographical zones of India.

Suggested Readings:

1. Ecology: From Individuals to Ecosystems (5th Edition) by Michael Begon, Colin R. Townsend, ISBN: 978-1-119-27935-8, December 2020
2. Elements of Ecology by Thomas Michael Smith, Robert Leo Smith, 2012
3. Ecology: The Experimental Analysis of Distribution and Abundance. Pearson New International Edition. By Charles J. Krebs, 2013

BOT2PCOR08T
ADVANCED AND TRANSLATIONAL PLANT BIOLOGY (50 Marks)

Course outcome: This is another very much contemporary area absolutely essential for research in plant sciences. We intend to expose our students to state-of-the-art knowledge in this specific area, that may make them aware with current major translational research themes, highly encouraged and promoted by Govt. of India. Without the exposure to the latest knowledge of these themes, students will become handicapped academically. This course also will enrich students with innovative ideas for building their own start-up ventures, if they wish to carry out in their future academic/research careers in the current scientific scenario, with adequate preliminary financial support from Indian Govt.

Course details:

BioE3 Policy (Biotechnology for Economy, Environment, and Employment):

Brief overview: Key linkages of the BioE3 Policy and Plant Sciences: Climate-Resilient Agriculture, Smart Proteins and Functional Foods, Bio-based Products and Chemicals; Plant Genome Research, Bio-foundries and Genetic Resources to highlight plant-centric industrial approach, directly applying botanical knowledge to economic, environmental, and employment goals.

Blue Economy and Blue Revolution:

Blue economy model and key projects in India; Botanical components in the Blue Economy, and its role in the Blue revolution; Pradhan Mantri Matsya Sampada Yojana- significant intersections with botanical sciences.

Biobased (Circular) Economy:

Brief overview, potential applications from botanical perspective in Renewable Feedstock; Waste Valorization; Regenerative Agriculture; Biodegradable Materials; Carbon Capture, Sequestration & Storage (CCUS); Some examples in action-Industrial Use: Turning wood, algae, or crop waste into construction materials, chemicals, or energy; Agricultural Improvement: Using mycorrhizal fungi to enhance plant nutrient uptake; Reducing reliance on chemical fertilizers: Natural Farming; Waste-to-Value: Transforming agricultural residues (e.g., corn cobs) into valuable industrial chemicals.

Commercialisation of Bio-based Products:
Initiation of a startup for plant-based products; the whole concept: License, funding, and marketing; Recent Examples of Algae-Based Innovations Products, Cloth dyes, Papers, Everyday use items, Medicinal products, Bioplastics, Natural Colorants and Pigments; Nutritional Supplements and Cosmetics; Biofertilizers and Soil Conditioners; Wastewater Treatment Agents; Biorefinery applications; Fungal innovations: Mycelium-based Textiles (Leather Alternatives); Insulation and Construction Materials, Packaging Materials; Food and Nutritional Products beyond traditional mushrooms; Biocontrol Agents; Future Challenges in production and commercialization.

National Initiatives and Regulatory Bodies:
Nutritional Security through Intensive Millets Promotion (INSIMP); AYUSH large-scale cultivation of 140 prioritized medicinal plant species- Commonly cultivated prioritized species and high-value & subsidy-specific species; National Mission on Natural Farming (HMNF), Key Miyawaki forest projects in India; National-Level Initiatives and Integration.
Regulatory Bodies: BioRRAP (Biological Research Regulatory Approval Portal); National Biodiversity Authority (NBA).
Translational Methodologies and Application:
GM Crops: Methods, scope, limitations/challenges; Genome-edited crops; Precision agriculture: Application of IoT and AI models in precision agriculture.
Genome editing: Biology, Tools/technologies: TnPB (Transposon-associated Protein B), ISDra2TnpB variant: Indigenous and IP-free alternative to globally patented CRISPR-Cas systems; Non-coding RNAs: Description, types, mechanisms (Basic biology): Applications in plants; Global warming and resilient crops.

BOT2PCOR09T
INDUSTRIAL AND ENVIRONMENTAL MICROBIOLOGY (50 Marks)

Course outcome: This is a contemporary area absolutely essential for research in microbial sciences. We intend to expose our students to state-of-the-art knowledge in this specific area, which may make them aware of current major translational research opportunities and employment scopes, highly relevant in the present-day scenario. Without exposure to the latest knowledge on these themes, students will be academically disadvantaged. This course will also equip students with innovative ideas in industrial and environmental microbiology to build their own start-up ventures or to engage with pharmaceutical companies and other industries for employment, if they wish to pursue their future academic/research careers under the current scientific scenario.

Course details:

Industrial Microbiology: 30 Marks

Scope of microbes in industry and environment: Isolation of Industrially Important Microbes.
Bioreactors/Fermenters and fermentation processes: Fermentation process optimization; Media formulation (C, N source); Strain improvement; Solid-state and liquid-state (stationary and submerged) fermentations; Batch and continuous fermentations; Components of a typical

bioreactor; Types of bioreactors-laboratory, pilot scale and production fermenters; Constantly stirred tank fermenter, tower fermenter, fixed bed and fluidized bed bioreactors and air-lift fermenter.

Microbial production of industrial products: Microorganisms involved, media, fermentation conditions, downstream processing and uses; Filtration, centrifugation, cell disruption, solvent extraction, precipitation and ultrafiltration, lyophilization, spray drying; Hands on microbial fermentations for the production and estimation (qualitative and quantitative) of Enzyme: amylase or lipase activity, Organic acid (citric acid or glutamic acid), alcohol (Ethanol) and antibiotic (Penicillin).

Microbial enzymes of industrial interest and enzyme immobilisation: Microorganisms for industrial applications and hands-on screening microorganisms for casein hydrolysis; starch hydrolysis; cellulose hydrolysis. Methods of immobilisation, advantages and applications of immobilization, large-scale applications of immobilised enzymes (glucose isomerase and penicillin acylase).

Environmental Microbiology: 20 Marks

Microbes and the Quality of the Environment: Distribution of microbes in air; Isolation of microorganisms from soil, air, and water.

Microbial flora of water: Water pollution, role of microbes in sewage and domestic wastewater treatment systems. Determination of BOD, COD, TDS, and TOC of water samples; Microorganisms as indicators of water quality, check coliform and faecal coliform in water samples.

Microbes in agriculture and remediation of contaminated soils: Biological fixation; Mycorrhizae; Bioremediation of contaminated soils; Isolation of root nodulating bacteria; arbuscular mycorrhizal colonization in plant roots.

Suggested Readings:

1. Pelzar, M.J. Jr., Chen E.C. S., Krieg, N.R. (2010). Microbiology: An application-based approach. Tata McGraw Hill Education Pvt. Ltd., Delhi.
2. Tortora, G.J., Funke, B.R., Case. C.L. (2007). Microbiology. Pearson Benjamin Cummings, San Francisco, U.S.A., 9th edition.

BOT2PCOR10P
LABORATORY COURSE (50 marks)

Course outcome: This laboratory course aims to make the student familiar with some of the hands-on training on relevant experimental techniques of the three theory courses of Semester II.

(i) Handle and analyze plant and diseased materials in the laboratory/herbarium and in the field.
(ii) Use scientific terminology accurately through effective oral and written communication and the use of dichotomous keys in a regional floristic manual
(iii) Have expertise in techniques related to plant pathology and plant fossils as well as their handling techniques

Course details: The relevant experiments will be based on the three theory courses of Semester II.

PLANT SYSTEMATICS:

Workout of plant specimens and description of vegetative and reproductive characters from representative locally available families. Classification based on APG III, 2009: Basal Angiosperm
and Magnolids: Monocots: Commelinids: Basal Eudicots and Lamids, Campanulliids, Rosids, Asterids.

• Training in using local floras and other literature and herbaria for identification of specimens described in the classes.

• Study of different taxa, selection of key characters and preparation of keys at generic and specific
level.

• Phylogeny analysis using R based/open sourced or proprietary software (PAUP, etc).

• Cladogram construction and analysis

• Techniques in molecular systematics

• Field excursion for familiarization with and study of vegetative types (s) and flora(s) of areas outside and with the state and training in collection and preservation methodologies.

PLANT ECOLOGY AND ENVIRONMENTAL BIOLOGY-I:

• Study of morphological and structural adaptation of locally available hydrophytes, mesophytes,
halophytes, and epiphytes and correlate to their particular habitats.

• Hydrophytes: Nymphaea, Hydrilla Xerophyte: Nerium, Casuarina Mesophyte: Tridax, Vernonia.
Halophyte: Avicennia, Rhizophora. Epiphyte: Vanda

• Assessment of density, frequency and abundance of plants in a community using various techniques
i.e. transect, quadrat etc.

• Field trips for study and observation of vegetational types under the guidance of a teacher.

• Map of the phytogeographical region of India.

• Study of some endangered plant species and their conservation.

• Understanding ecosystem succession by studying various stages of vegetation/community
assemblages development.

• Principle of GIS and RS technology

• Basic GIS, Visual interpretation of different types of vegetation. Delineation of ecosystems using
GIS technology, temporal dynamics and models. Gymnosperms:

• Study of leaf and wood anatomy of available specimens.

• Study of male and female reproductive structures of available specimens.

INDUSTRIAL AND ENVIRONMENTAL MICROBIOLOGY:

1. Principles and functioning of instruments in a microbiology laboratory
2. Hands-on sterilization techniques and preparation of culture media.
3. Isolation of bacteria from soil for
   a) Starch hydrolysis (Amylase)
   b) Caesin hydrolysis (Protease)

c) Cellulose hydrolysis (Cellulose)

4. Isolation of antibiotic-producing bacteria
5. Isolation of antibiotic-resistant bacteria.
6. Comparison of microbial flora from different (at least 3) soil/water sources.
7. Determination of BOD, COD, TDS, and TOC of water samples.
8. Bacterial examination of water by MPN method.
9. A visit to any educational institute/ industry to see an industrial fermenter, and other downstream processing operations, and submission of a report

Semester-III

BOT2PCOR11T
DIVERSITY OF MICROBES (BACTERIA, VIRUSES, FUNGI, OOMYCETES), PLANT PATHOLOGY & CROP PROTECTION (50 MARKS)

Course outcome: Upon successful completion of this course, the student will be able to

-Understand the general structure and functions of the prokaryote, microbial genetics

-Understand the architecture of viruses, their classification and the methods used in their study, general replication strategies of viruses,

-Comprehend the plant viruses that can be used as tools to study biological processes, and understand the different assay and purification techniques of the plant viruses.

-Understand that Fungi and oomycetes are among the most important eukaryotic microbes on Earth, and they are among the most diverse and widespread groups of parasites in terrestrial and aquatic habitats.

-Understand the molecular mechanism of host –pathogen interaction, disease resistance, and its translational use for the development of disease-resistant plants through genetic engineering

Course Details

Diversity of Bacteria: Current classification, bacterial diversity; Prokaryote cell structures- Eubacteria and Archaebacteria; Bacterial genetic mutation, mutagenesis, recombination and transposition; DNA repair mechanisms; Plasmids, F plasmids and conjugation; Transformation and transduction; Bacteria in the Environment; Bacterial Plant Pathogens: types, diseases and mechanisms of pathogenesis- Introduction.

Diversity of Viruses: Principles of Plant Viral Taxonomy, Classification; Origin, and Evolution; Virus replication, variability, transmission, movement and host range; Host response to plant infection; Small nucleic acid molecules that cause or modify diseases; Different vectors of plant viruses & Epidemiology; Plant virus as vector; Assay and purification of virus particle; Virus-induced gene silencing (VIGS).

Diversity of Fungi & Oomycetes: Modern trends in classification; phylogeny, affinities and the position of Fungi and Oomycetes in modern systematics; General account, structure organisation, ultrastructure of fungal cell, and distinctive features; *Saccharomyces cerevisiae*- a model to study fungal genetics and molecular biology; Mutualistic associations: Lichen, a general account and economic importance; interactions of phycobionts and mycobionts; Mycorrhiza Types and Agricultural Importance; Oomycete diversity in various ecological habitats; Oomycete genetics and genomics- A brief idea about genetic resources available and their uses.

Plant Pathology: Mechanism of disease resistance; General idea about the architecture of plant immunity, morphological, anatomical, biochemical and molecular host defence mechanisms against pathogens and pests; Corollary of the Gene-for-Gene hypothesis; Concept and structure of *R* gene,/NLR and *avr*/effector; Genetic basis of differentiation of host, non-host and marginal host; Concept of hybrid necrosis; Qualitative and Quantitative resistance- Hypotheses and mechanisms; Host-pathogen interaction: recognition pathways-direct and indirect (ETI, PTI, ETS), DAMP mechanisms, differentiating between the responses to biotrophs, necrotrophs & herbivores; Role of *NPR1*, *NPR3/4* genes in cross-talk of systemic acquired resistance, induced systemic resistance; Cloning of resistance genes (R genes) and avirulence genes (*Avr*) from plants and pathogens, and genetic engineering for the production of resistant plants to pathogens and pests.

Crop Protection: Control of plant diseases: exclusion, eradication, protection and therapy; fungicides- inorganic and organic; protectants and systemic fungicides and their mode of action; Fungicide resistance, FRAC; Cultural and biological control.

Suggested Readings:

1. The Fifth Kingdom: Bryce Kendrick, 4th Edition

2. Bryophyte Biology: A. Jonathan Shaw & Bernard Goffinet, 2nd edition.

3. Introduction of Plant Viruses: Mandahar, C.L.Chand& Co. Ltd. Delhi.

4. Introduction to Fungi: John Webster, Roland Weber, 2007. Cambridge University Press.

5. **Oomycete Genetics and Genomics: Diversity, Interactions and Research Tools**. Lamour, K. and S. Kamoun, Eds. 2009. Wiley-Blackwell, Hoboken, NJ

6. Introduction to Plant Pathology: Richard N Strange. Wiley

7. Plant-Associated Bacteria. Eds: Samuel S. Gnanamanickam. Springer Netherlands

8. **Molecular Plant Pathology**: Matthew Dickinson, BIOS Scientific Publishers, London

9. Plant Pathology: G.N. Agrios. 5thEd.Academic Press

10. Essential Plant Pathology: Gail L. Schumann and Cleora J. D'Arcy.2nd Ed. APS Press, USA

Suggested journals:

eLife, Nature Reviews, BioEssays, Trends in Plant Science, Annual Reviews

BOT2PCOR12T

DIVERSITY OF PLANT LIFE (ALGAE, BRYOPHYTES, PTERIDOPHYTES, GYMNOSPERMS, PALAEOBOTANY & PALYNOLOGY) (50 marks)

Course outcome: Completion of the course will

(i) familiarize the student with diversity of the major life forms of pteridophytes and gymnosperms as well as their fossil members. Their biology, phylogeny, interrelationships, role in environment as well as their commercial uses and industrial applications.

(ii) equip the student to understand the evolutionary interrelationships between these groups and angiosperms both from extant and extinct genera.

Course details:

Diversity of Algae

Diversity & distribution of algae: Brief account of distribution of algae in India; *Chlamydomonas reinhardtii* (genomic model) and *Porphyra* as experimental systems.

Classification: Molecular taxonomy- recent developments in algal classification.

Algal Biotechnology: Historical perspectives, aquaculture (micro and macro algae cultivation); bioremediation, recent developments and future of algal biotechnology; Algal bio-fuels & algal biodiesel, bio-ethanol and biological hydrogen production; algae in global warming; carbon capture by algae.

Industrial Phycology: Products, processes and applications, sea weeds polysaccharides like agar, Carrageenan and Alginates; Bioactive compounds from algae; algal bio fertilizers; algae in bioengineering; algal photo-bioreactors and raceway ponds.

Diversity of Bryophytes

Classification: Modern classification of Bryophytes (Shaw and Goffinet) with general characters up to order level; Origin and Evolution of Bryophytes.

Poikilohydry, Desiccation tolerance.

Breeding systems, Genetics, Physiology: Breeding systems; Cytogenetics of bryophytes;

Ecology, Economic uses & conservation: Role of bryophytes in ecosystem dynamics and in the global carbon budget; Bryophyte chemistry and its taxonomic implications; Biologically active compounds in bryophytes.

Diversity of Pteridophytes

Diversity: Morphological diversity and evolution of vegetative organs in Pteridophytes; Diversity of ferns-an ecological perspective, endangered, endemic pteridophytes and their conservation.

Chemistry, Physiology: Chemical nature and mode of action of *Antheridogens;* Photomorphogenesis; Model system in *Ceratopteris*, *Selaginella moellendorfii, Osmunda* and *Marsilea.*

Diversity of Gymnosperms

Evolution: Evolution of pollination mechanisms and embryogeny of gymnosperms with reference to Cycadales, Coniferales, Ginkgoales, Taxales and Gnetales.

Physiology, metabolism: Acclimatization and adaptive responses to conifers to environmental stresses; Drought tolerance and cold hardiness, stimulation of reproductive growth seed and seedling ecology.

Use: Conifer plantation as seed trap, impact of coniferous forest on human life.

Palaeobotany

Basic geological information related to Palaeobotany: Major types of rocks, taphonomy, nomenclature and reconstruction of fossil plants; principles of stratigraphy.

Dating of rocks: Principles of relative and absolute dating of fossils.

Origin and evolution of plant life forms: Brief idea of origin of life; first prokaryotes; evolution of eukaryotes.

The colonisation of land: Land adaptive features, evolution of land plants and different evidences.

Emergence of seed plants: Evolution of closed carpels, evidences from the ovulate fructifications of Glossopteridales, Corystospermales, Caytoniales, Bennettitales, Pentoxylales.

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

Palynology

Branches of Palynology: spore, pre-pollen and pollen morphology; wall chemistry; evolution of aperture types; application of neopalynology and palaeopalynology; ancient DNA and other fossil biomolecules in evolutionary research.

Suggested Readings:

1. Phycology: Robert Edward Lee, 3rd Edition.
2. Algae: An Introduction to Phycology: Christissn Hoek, D.G.Mann, HansMartin Jahns.
3. Algal Culturing Techniques: edited by Robert A. Andersen
4. The Fifth Kingdom: Bryce Kendrick, 4th Edition
5. Bryophyte Biology: A. Jonathan Shaw & Bernard Goffinet, 2nd edition.
6. Mosses, liverworts and hornworts: status survey and conservation action Tomas Hallingbac, N.G.Hodgetts, IUCN/SSC
7. Introduction of Plant Viruses: Mandahar, C.L.Chand& Co. Ltd. Delhi.
8. Introduction to Fungi: John Webster, Roland Weber, 2007. Cambridge University Press.
9. Oomycete Genetics and Genomics: Diversity, Interactions and Research Tools. Lamour, K. and S. Kamoun, Eds. 2009. Wiley-Blackwell, Hoboken, NJ

Suggested journals:

eLife, Nature Reviews, BioEssays, Trends in Plant Science, Annual Reviews

BOT2PCOR13T

MOLECULAR CELLULAR GENETICS & PLANT BREEDING (50 marks)

Course outcome: Upon successful completion of the course, students will be able to:

- Explain the principles of classical and molecular genetics.
- Describe genome organization, gene regulation, and epigenetic mechanisms.
- Interpret modern plant breeding approaches for crop improvement.
- Apply genetic and breeding concepts to research and sustainable agriculture.

Course details:

Classical and Population Genetics

Classical Genetics: Chromosome theory of inheritance; Mendelian laws of inheritance; Gene interactions; Meiosis and its genetic significance; Linkage and crossing over; Chiasma formation and genetic map distance; Tetrad analysis and centromere mapping.

Non-Mendelian Inheritance: Cytoplasmic (organelle) inheritance; Maternal inheritance.

Population Genetics: Hardy-Weinberg equilibrium, Gene and genotype frequencies, Factors affecting genetic equilibrium, Applications in plant breeding

Sex Determination: Genetic mechanisms of sex determination in plants; Sex-linked inheritance, Dosage compensation

Chromosome Biology, Mutation and Epigenetics

Chromosome Organization: Structure and morphology of chromosomes; Centromere and telomere; Special chromosomes (Lampbrush, Polytene).

Chromosomal Aberrations: Deletion, Duplication, Inversion, Translocation, Aneuploidy and polyploidy, Genetic significance.

Mutation: Types and causes of mutations; Physical and chemical mutagens; Germinal and somatic mutations; Loss-of-function and gain-of-function mutations; Insertional mutagenesis.

Recombination: Homologous recombination, non-homologous recombination.

Epigenetics: Introduction to epigenetics; DNA methylation; Histone modifications; Chromatin remodelling.

Molecular Genetics and RNA Biology

Gene Regulation: Gene concept and gene organization; Transposable elements; IS elements; Composite transposons; Ac/Ds elements, P-elements.

RNA Biology: RNA editing; gene silencing through antisense RNA technology and Ribozymes; RNA interference (RNAi) by small regulatory RNAs; different types of small non-coding RNAs; their biogenesis and functions in posttranscriptional gene silencing; applications of RNAi in crop quality improvement.

Molecular Plant Breeding and Quantitative Genetics

Self-Incompatibility and Male Sterility: Types, Genetic and molecular basis; Cytoplasmic male sterility (CMS); Genic male sterility (GMS); Transgenic approaches; Applications in hybrid seed production.

Quantitative Genetics: Phenotypic variance; Genotypic variance; Environmental variance; Broad-sense heritability; Narrow-sense heritability; Applications in breeding.

Biostatistics for Genetics: Chi-square (χ^2) test, Goodness of fit; Segregation ratio; Linkage analysis; Test of independence, Student's t-test, Paired t-test; Analysis of Variance (ANOVA); Correlation, Regression.

Suggested Readings:

1. Concepts of Genetics- Klug W.S., Cummings M.R., Spencer C.A. & Palladino M.A. (Pearson International Edition)
2. Essential Genetics- A Genomic Perspective- Hartland D.L. & Elizabeth W.J. (Jones & Bartlett publishers)
3. Genes IX- Lewin Benjamin (Jones & Bartlett publishers)
4. Genetics- A Conceptual Approach- Pierce B. (W.H. Freeman & Co.)
5. Genetics- Analysis of genes and genomes- Hartland D.L. & Elizabeth W.J. (Jones & Bartlett publishers)
6. Genetics- from genes to genomes- Hartwell (Tata McGraw-Hill Int. Edition)
7. Genetics- A Molecular Approach- Peter J. Russell (Pearson Int. Edition)
8. Molecular Cell Biology- Lodish H, Berk A, Kaiser C.A., Krieger M., Scott M.P., Bretscher A., Ploegh H. &Matsudaira P. (W.H. Freeman & Co.)
9. Principles of Gene Manipulation & Genomics- Primose S.B. &Twyman R.M. (Blackwell publishing)
10. Principles of Genetics- Snustad D.P. & Simmons M.J. (John Wiley & sons Inc.)
11. Principles of Genetics- Tamarin R.H. (Tata McGraw-Hill edition)
12. Molecular Cell Biology, Lodish, Harvey; Berk, Arnold; Zipursky, S. Lawrence; Matsudaira, Paul; Baltimore, David; Darnell, J. E. New York: W.H. Freeman & Co.
13. Cell And Molecular Biology: Karp Gerald, Cbs Publisher & Distributor.
14. The Cell - A Molecular Approach, Cooper, Geoffrey M. Sunderland (MA): Sinauer Associates, Inc.
15. Molecular Biology of the Cell, Alberts, Bruce; Johnson, Alexander; Lewis, Julian; Raff, Martin; Roberts, Keith; Walter, Peter New York and London: Garland Science.
16. Cell and Molecular Biology: De Robertis, E.D.P. and De Robertis Jr, E.M.F. 2001.
17. Biochemistry & Molecular Biology Of Plants, Russell L. Jones, Wilhelm Gruissem, Bob B. Buchanan, John Wiley & Sons.
18. Lehninger principles of Biochemistry, Albert L. Lehninger, David Lee Nelson, Michael M. Cox, W.H. Freeman
19. Bhojwani, S.S. and Razdan, M.K. 1996. Plant Tissue Culture: Theory and Practice (a revised edition). Elsevier Science Publishers, New York, USA.

20. Bojwani, S.S. 1990. Plant Tissue Culture: Applications and Limitations, Elsevier Science Publisher, New York, USA.
21. Collins, H.A. and Edwards, S. 1998. Plant Cell Culture, Bios Scientific Publishers, Oxford, UK.
22. George E.F., Hall M.A. and Klerk J.D. Plant Propagation by Tissue Culture (3rd Ed.), Springer
23. Khasim, S.M. 2002. Botanical Microtechnique: Principles and Practice, Capital Publishing Company, New Delhi.
24. Vasil, I.K. and Thorpe, T.A. 1994. Plant Cell and Tissue Culture, Kluwer Academic Press, The Netherlands.
25. Principles of Plant Breeding, Allard R.W., John Wiley & Sons.
26. Plant Breeding, PoehlmanJ.M. &Barthakur D., Oxford & IBH.
27. Plant Breeding- Principles and Methods, Singh B.D. Kalyani Publishers.
28. Principles and Practice of Plant Breeding, Sharma J.R., Tata McGraw Hill.
29. An Introduction to Plant Breeding, Jack Brown, Peter Caligari, WileyBlackwell
30. Molecular Marker Systems in Plant Breeding and Crop Improvement, Lörz, Horst; Wenzel, Gerhard (Eds.), Springer.
31. Biostatistical analysis, Zar JH. Englewood Cliffs, NJ. Prentice
32. Basic Biostatistics and its Application. Animesh K. Datta. New Central Book Agency (P)

BOT2PCOR14T
PLANT PHYSIOLOGY & BIOCHEMISTRY (50 marks)

Course outcome:
This course covers the general aspects of plant physiology and biochemistry. Plants maintain a unique physiological system through photosynthesis, photorespiration, nitrogen fixation, plant-specific growth hormone control, etc., and we introduce students to this arena through this course. Students will acquire the basic physiological and biochemical knowledge of plant systems that will help them build up their further concepts, and will be knowledgeable enough to choose their elective courses in the next semester, depending on their understanding of the relevant subject.

Course details:

Basic Biochemistry: pH, pK and pI; Carbohydrate, Protein and Lipid structures: Types, Hierarchy, Saturation and unsaturation, Folding, Functional characterization; Application of principles of thermodynamics in biology; Regulation of enzymatic activity, types of inhibition and concept of $K_{m,}$ V_{max}.

Transport of water and nutrients: Apoplastic and symplastic transport mechanisms; Role of aquaporins and transporter proteins; Structure-function relationship of inward and outward ion channels, dual action of ATPases/pumps and modulation of their activity; Specialized mechanisms for phosphorus and iron uptake, monitoring of ion channel activity.

Photosynthesis: Light-dependent and light-independent reactions; Complexes of electron transport in chloroplast, Z scheme, Two-Photosystem concept, Q-Cycle; Generation of proton gradient coupled to ATP generation; RuBISCO Activase, Calvin Cycle; CO_2 concentrating mechanism in plants, regulation of C3- C4 and CAM cycles; Regulation in sucrose synthesis; Light Response Curve, CO_2 Response Curve, Sun and Shade plants; Non-photochemical Quenching (NPQ); Xanthophyll Cycle, State Transition Theory; Photosynthetic Efficiency, NPQ,

PQ Measurement via Pulse Amplitude Modulated (PAM) Chlorophyll Fluorescence; Retrograde gene regulation; Electron Transport Chain inhibitors; Stable Carbon Isotope Ratio in characterizing C3 & C4 photosynthesis.

Respiration and photorespiration: Steps and metabolic regulation of Glycolysis; Pyruvate Dehydrogenase Complex, Kreb's cycle, Pentose Phosphate Cycle, Gluconeogenesis, GABA Shunt and Glyoxylate cycle; Plant mitochondrial electron transport, its inhibitors and ATP synthesis; Alternate oxidase; C_2 Photorespiratory pathway, Glycine decarboxylase complex; Alternatives to C_2 Photorespiratory Pathway.

Nitrogen metabolism: Nitrate and ammonium assimilation; Amino acid biosynthesis; Structure and function of nitrogenase, *nif* genes and nod gene organization.

Sensory Photobiology: Photoperiodism; Structure, function and mechanisms of action of phytochromes, cryptochromes and phototropins; Circadian Rhythm, Vernalization and Flowering.

Plant hormones: Biosynthesis, storage, breakdown and transport of plant growth regulators; Physiological effects and mechanisms of action and use of mutants in understanding hormone actions; Hormones in defense against abiotic and biotic stresses; Hormone signalling in plant systems.

Stress physiology: Types of environmental stresses; Plant responses to abiotic stress: osmotic adjustment and its role in tolerance to drought and salinity, impact of salinity, water deficit, cold (Freezing) and heat stress on plants and molecular basis of acclimation strategies; Introduction to biotic stresses and types of plant resistance to pathogens: R gene resistance, preformed inhibitors of pathogens, gene for interaction in plant defense, Systemic Acquired Resistance (SAR) and Induced Systemic Resistance (ISR); Oxidative and nitrosative stress and antioxidative strategies: causes and effects, nitric oxide biosynthesis and metabolism, NO-mediated signalling, Formation of ROS and its role in plant's defense and signalling; Flooding and hypoxic/anoxic stresses and plant's acclimative responses.

Suggested Readings:

1. Introduction to Plant Physiology: William G. Hopkins and Norman P.A. Huner. (Fourth Edition) 2008. John Wiley& Sons, Inc.

2. Biochemistry and Molecular Biology of Plants, 2nd Edition

Bob B. Buchanan (Editor), Wilhelm Gruissem (Editor), Russell L. Jones (Editor)

ISBN: 978-0-470-71421-8. July 2015**.**

3. Lehninger Principles of Biochemistry: David L. Nelson and Michael M. Cox.(Fifth edition) 2009. W. H. Freeman publication.

4. Biochemistry: Jeremy M. Berg, John L. Tymoczko, Lubert Stryer. (Fifth edition). 2002. W.H. Freeman publication.

5. Plant Physiology and Development:

By Lincoln Taiz, Ian Max Møller, Angus S. Murphy, Eduardo Zeiger, 2023, Sinauer Associates (7th Edition)

Related review articles in the following Journals:

_ Annual Review of Plant Biology
_ Critical Reviews in Plant Science
_ Current Opinion in Plant Biology
_ Trends in Plant Science
_ Plant Physiology, Plant Cell

BOT2PSEC01M **SEC**

Any one of the following:

a) TREE AND WOOD BIOLOGY (50 marks)

Course outcome: The goal of the course program is to produce students with scientific knowledge needed for the biology, cultivation and management of trees and the development of trees in forest stands, and a stewardship ethic needed for sustainable manage of woods products, recreations opportunities, biological diversities, water and other ecosystem services.

Course details:

Tree Biology General: Trees, Tree Classification, Nomenclature; Tree identification; Tree growth; Tree age; Endangered trees; Champion Trees; Veteran Trees; Woodland Management: specific examples; Decision Support Tools.

General concepts of Tree improvement: Variation and its use; Provenance and seed sources; Quantitative aspects of tree improvement; Quantitative genetic Selection; Genetical and Statistical consideration; Selection in natural stands and unimproved plantation.

Orchard: Seed orchard, Clonal seed orchard and Seed production.

Genetic testing programs: Mating design; Experiment design; Analysis of genetic tests; Genotype and Environmental interaction; Selection and Breeding for: Resistance to disease, Insects, Adverse environments.

Elite tree: Vegetative propagation; Hybrids in tree improvement; Genetic base and Gene conservation.

Wood: Physical properties; Growth ring, Knots, Heartwood and sapwood; Colour, Water contents, Structure, Early wood and late wood; softwood, ring porous wood, Monocot wood; Specific gravity; Wood density; Hard and soft woods; Chemistry of woods; Uses; Wood anatomy: Resin canals, Tracheids, Early wood to late wood transition, Grains contrast, Parenchyma, Rays; Macroscopic feature for Hardwood and Softwood identification.

OR

b) BIODIVERSITY AND CONSERVATION (50 marks)

Course outcome: This course provides an understanding of the concept and principle of biodiversity science, causes as well as current crisis, and consequences of biodiversity loss. The course provides a conceptual understanding of various means of conservation, restoration and sustainable utilization of biodiversity which can provide viable solutions to a range of societal challenges and provides an effective tool to bridge the knowledge gap for sustainable management of biodiversity. The course also explores the linkages between biodiversity conservation, ecosystem services, climate change and sustainable livelihood.

Course details:

Biodiversity: Global and Indian; What is biodiversity? Types of Biodiversity; Climatic Zones and Biodiversity; Biodiversity as a natural resource; Indian Biodiversity; Vegetational Zones; Zones of Faunal distribution; Global Biodiversity; Major Biodiversity areas of the world;

Biodiversity Hot Spots; Threatened species, Red Data Book and its significance, Urban Biodiversity: Biodiversity in cities & towns, Concept of opportunistic species.

Concept of conservation: Agricultural conservation; Conserving species of Economic significance; Significance of gene banks and germ plasm conservation; Use of wild species for producing improved hybrid varieties; Seed Banks & Artificial seeds in conservation; Important International conventions & treaties on nature & conservation; India's role & contribution (including VISION 2040); *Ex- situ* & *In-situ* conservation; Conservation Breeding (e.g. Vulture, Pygmy hog, Gharial etc.); Institutions and their role in conservation: Zoos, Natural history museums & collections (including iconic international ones) National Institutions: Zoological Survey of India, Botanical Survey of India, Forest Research Institute, National Bureau of Plant Genetic Resources, Central Marine Fisheries research Institute.

People and conservation: Traditional knowledge Traditions & cultures; Women in conservation- Traditional Societies (e.g. Bishnois); Role of NGOs in conservation International NGOs; UNEP, GEF, WCS, Bird Life International Important NGOs in India & their contributions WWF, ATREE, BNHS, WTI, Kalpavriksha etc. Important NGO movements, Chipko movement, Narmada BachavoAandholan, PaniPanchayats, Seed Movement etc.

Wild life protection: Major protected areas & their importance; Protected Areas and People's Participation in their sustenance; Wildlife Trade and Laws: Wildlife protection Act of India: CITES, TRAFFIC. Measures to control poaching & wildlife trade; Regulations & Acts related to protected areas General concepts of Private forests, Reserve forests, Sanctuaries, National Parks, Wildlife reserves, Coastal Regulation Zone Protected Areas Network.

BOT2PCOR15P

LABORATORY COURSE (50 Marks)

Course outcome: This laboratory course aims at making the student familiar with some of the hands-on trainings on relevant experimental techniques of the four theory courses of the semester III such as, diversity of microbes (bacteria, viruses, fungi, oomycetes), plant pathology & crop protection, diversity of plant life (algae, bryophytes, pteridophytes, gymnosperms, palaeobotany & palynology), molecular cellular genetics & plant breeding and plant physiology & biochemistry.

Course details: The relevant experiments will be based on the four theory courses of the semester III such as, diversity of microbes (bacteria, viruses, fungi, oomycetes), plant pathology & crop protection (BOT2PCOR11T), diversity of plant life (algae, bryophytes, pteridophytes, gymnosperms, palaeobotany & palynology) (BOT2PCOR12T), molecular cellular genetics & plant breeding (BOT2PCOR13T) and plant physiology & biochemistry (BOT2PCOR14T).

Semester-IV

Department Specific Electives (DSE) 50 Marks for each paper

One course each from BOT2PDSE01T and BOT2PDSE02T has to be taken by the student, and only the following combinations will be permitted.

Course combinations offered for DSE papers		
Course Codes	**BOT2PDSE01T**	**BOT2PDSE02T**
Combination 1	# Plant Virology & Molecular Mycology	# Molecular Plant Pathology
Combination 2	# Molecular Genetics & Advanced Cell Biology	# Applied Plant Breeding & Plant Tissue Culture
Combination 3	# Advanced Plant Physiology & Biochemistry	# Plant Molecular Biology
Combination 4	# Angiosperm Taxonomy & Biosystematics	# Plant Ecology and Environmental Biology-II

Combination 1
BOT2PDSE01T
(i) PLANT VIROLOGY & MOLECULAR MYCOLOGY (50 marks)

Course outcome: Upon successful completion of this course, the student will be able to
(i) Understand the economic and pathological importance of plant viruses, their nature and properties, classification, how virus evolution takes place, as well as those of virus-like entities, the role of satellite viruses and satellite RNAs and viroids in plant diseases.
(ii) Understand the different diseases caused by the viruses, symptomatology, transmission, purification, assay, characteristics and control measures of representative viruses.
(iii) Understand the diversity and role of Fungi and Oomycetes in the environment, their biology, interrelationships, genome organisation, commercial uses and the biological resources available for their study.

Course details:

Plant Virology:

Virus nomenclature: Nature and properties of viruses and virus-like entities; Symptomatology, transmission, purification; characters and classification of Potyvirus, Potexvirus, Geminivirus, Orthotospovirus, Tobamovirus.

Transmission of plant viruses: Seed, pollen, soil, water and vegetative materials; Vector transmission by organisms other than arthropods; Arthropod transmission-types and characteristics, mechanisms and accessory factors; Plant virus-based vector.

Viruses and Virus Diseases of Plants: ss(+)RNA viruses; Detailed examples: Tobamoviruses, Potyviruses, Closteroviruses; ss(-)RNA and dsRNA viruses: Detailed examples: Rhabdoviruses and Reoviruses, Tosposviruses and Tenuiviruses; ssDNA and dsDNA viruses: Detailed examples: Geminiviruses and Nanoviruses, Caulimoviruses; Satellite viruses; satellite RNAs, and Viroids. Variability of plant viruses and strains; Evolution of plant viruses; mechanism of resistance; genetic engineering, ecology, and management of plant viruses.

Molecular Mycology:

Fungi Origin, interrelationship: Origin of fungi and their interrelationships; modern methods of classification; Oomycete diversity, interrelationships & biology.

Genetic variation in fungi: Heterokaryosis, parasexual cycle and their significance; Detection of genetic variation in populations.

Adaptations in Fungi: Thermophilic fungi; Photoresponses and Circadian rhythm; Role of saprotrophs in ecosystems.

Nutrient sensing and uptake in fungi: Regulation of carbohydrate and nitrogen compound metabolism.

Diversity in life processes: Diversity of somatic, reproductive and fruiting structures and life cycle patterns in different groups of fungi- Myxomycotina, Mastigomycotina (with special reference to sex hormones); Zygomycotina, Ascomycotina (with special emphasis on ascocarps and methods of dispersal); Basidiomycotina (with special emphasis on fruiting structures and methods of spore dispersal), Deuteromycotina (with special emphasis on sporulating structures and conidial ontogeny); Basic patterns of sexuality, heterothallism, parasexuality, Mycoviruses; Genetic control of vegetative growth, asexual, sexual development and senescence.

Genome organisation in fungi: Extra chromosomal inheritance in fungi; Retroposon and retrotransposon in fungi; Principles and general methods of gene manipulation in fungi; Regulation of protein synthesis in fungi; Heat shock protein and chaperon; Signal transduction pathways.

Repositories: Culture repositories and methods of preservation of fungal cultures; Mycological databases; GenBank repositories; open source computational and other internet resources for Mycologists and Plant Pathologists; searching and retrieving from databases.

BOT2PDSE02T
MOLECULAR PLANT PATHOLOGY (50 marks)

Course outcome: On completion of the course, the student will be knowledgeable about

(i) Principles of the epidemiology of diseases, molecular basis of how pathogens attack the plants and hijack their defences, how the plants perceive the pathogens and react to infection.

(ii) sustainable control methods, chemical control and their risks, and modern methods of development of disease-resistant varieties.

Course details:

Epidemiology of plant diseases: Disease pyramid-components, measurement and simulation of plant disease epidemics; forecasting and remote sensing; Decision Support systems (DSS); Epidemiology and ecology of plant pathogens.

Molecular basis of plant-pathogen interaction- physiology and genetics of plant-pathogen interaction; genetics of pathogenicity; Effector molecules and receptors, Indirect interaction-evolution of decoys; Plant receptor networks and crosstalk; Role of small RNAs (sRNA); Modern methods of transcriptome analysis.

Molecular biology of disease resistance: Host specific and non-specific toxin and molecular basis of their roles in pathogenicity; Plant chemicals (phenolics) involved in resistance: Hypersensitive (HR) reactions, Phytoalexins; pathogenesis related (PR) proteins, systemin; systemic acquired resistance (SAR), Induced Systemic resistance (ISR) and Pathogen-associated molecular patterns (PAMPs) and also role of Salicylic Acid (SA), Nitric Oxide (NO), Reactive Oxygen species (ROS), Concept of NLR/Resistosome.

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, Black stem rust of wheat, Blast of wheat, Early blight and Late blight disease of Potato, Wilt of Pigeon pea, White rust of Mustard, Anthracnose of Jute, Bacterial and Fungal Vascular wilt, Red rot of sugarcane, Citrus Canker, Tikka Disease of Groundnut, Little leaf of Brinjal, Root knot of Tomato.

Detailed case studies of Host-pathogen interactions of economically important causative agents with specific references to crop plants at molecular level:

Plant virus interactions: Potyvirus and horticultural crops; **Plant bacterial interactions:** *Ralstonia solanacearum* and solanaceous crops; **Plant nematode interactions**: *Meloidogyne* sp. and tomato;

Plant Oomycete interaction: *Phytophthora* and potato/ soyabean interaction; **Plant insect interactions**: *Pieris* sp. and crucifers; **Plant Fungi interaction**: *Magnaporthe grisea* and rice.

Development of disease resistant variety: Mutation breeding, marker assisted (MAS) breeding, recombinant DNA technology; RNAi in plant pathology and targeted genome editing in model and crop plants using the CRISPR/Cas system.

Serological methods for detection and characterization plant pathogens: Immunological assays.

Molecular diagnoses of plant pathogens: DNA-DNA hybridization; PCR amplification and finger printing.

Fungicides in disease control: topical and systemic fungicides; mechanism of fungicidal action-mode of action of systemic fungicides (belonging to some common chemical groups); application of fungicides.

Biological control by biotechnological methods: use of hyperparasite, hypovirulence plasmids and recombinant DNA technology.

Control of plant virus diseases; Biotechnology/genetic engineering; VIGS; Integrated disease management.

Suggested readings:

1. **Biochemistry & Molecular Biology of Plants** by Russell L. Jones, Bob B. Buchanan, Wilhelm Guissem John Wiley & Sons. American Society of Plant Biologists.
2. **Crop Diseases and their Management.** H.S. Chaube, V.S. Pundhir. Prentice Hall India Eastern Economy Edition
3. **Dictionary of the Fungi, 10th Edition** (September 2008) Edited by P M Kirk, CABI, UK; P F Cannon, CABI, UK; D W Minter, CABI, UK; J A Stalpers, CBS, Netherlands.
4. **Fungal Genetics**, David Moore, Lily Ann Novak Frazer, Springer (Indian Reprint) 2005
5. **Fungal Biology**, Deacon, Jim, Blackwell Publishing, 2005
6. **Fungal Morphogenesis**, Moore, David, Cambridge, 2002
7. **Fungi, Experimental Methods in Biology**, R. Maheswari, CRC Press, Taylor and Francis, 2005.
8. **Illustrated Dictionary of Mycology** by Miguel Ulloa and Richard T. Hanlin 2000; APS Press.
9. **Introduction to Fungi** John Webster with Roland W. S. Weber
10. **Introduction to Plant Pathology** Strange, RN (ed.): J. Wiley & Sons Ltd, Chichester, UK, 2003.
11. **Matthews' Plant Virology**, Roger Hull (Fourth Edition) 2002 Elsevier Ltd.
12. **Molecular Plant Pathology**, M. Dickinson (Division of Plant Sciences, University of Nottingham) Paperback Bios Scientific Publishers Ltd.
13. **Plant Pathology** G. N. Agrios
14. **Plant Associated Bacteria**, Eds. Samuel S. Gnanamanickam, 2007, Springer, The Netherlands.
15. **Recent Advances in Plant Virology**, Edited by: Carole Caranta, Miguel A. Aranda, Mark Tepfer and J.J. Lopez-Moya, Caister Academic Press, 2011
16. **The Fifth Kingdom** Third Edition (Paperback) by Bryce Kendrick
17. **The Fungi** Second Edition by Michael J. Carlile, Sarah C. Watkinson, Graham W. Gooday
18. **The Identification of Fungi**: An Illustrated Introduction with Keys, Glossary, and Guide to Literature by Frank M. Dugan APS Press.

Related review articles in the following Journals:

Trends in Plant Science, Trends in Biochemical Sciences, Theoretical and Applied Genetics, PNAS, Current Science, Bioessays, Current Opinion in Plant Biology, Fungal Genetics and Biology, Phytopathology, Annual Review of Phytopathology, Plant pathology, Mycologia, Molecular Plant pathology.

Combination 2
BOT2PDSE01T

i) PLANT MOLECULAR GENETICS & ADVANCED CELL BIOLOGY (50 marks)

Course outcome: Upon successful completion of the course, students will be able to:

- Explain genome organization and the molecular basis of gene expression.
- Describe the mechanisms of DNA replication, transcription, translation, and gene regulation.
- Interpret key concepts of cell cycle regulation, membrane transport, intracellular trafficking, and cell signalling.
- Apply principles of molecular genetics and cell biology in research and competitive examinations.

Course details:

Genome Organization, Genomics and Proteomics

Genome Organization: Prokaryotic and eukaryotic genome architecture; nuclear, mitochondrial and chloroplast genomes; genome size and complexity (C-value paradox); coding and non-coding DNA; gene families, pseudogenes; repetitive DNA.

Genomics: An overview; Genome sequencing strategies, genomes of Yeast; *Arabidopsis*, rice and human Genome annotation; Genome Duplication; Approaches to analyze differential gene expression-ESTs, Microarrays and their applications; Reverse genetics-Gene tagging, Gene trapping, Gene silencing, Knockout mutants, Transcriptomes.

Proteomics: Concept of proteome; Applications of proteomics: protein mining, protein-expression profiling, protein network mapping, protein modification and analysis.

Molecular Basis of Gene Expression and Genetic Regulation

DNA Replication: Molecular mechanisms of DNA replication in prokaryotes and eukaryotes; replication enzymes; replication fidelity and proofreading.

Transcription: Mechanism and regulation of transcription in prokaryotes and eukaryotes; RNA polymerases; transcription factors.

Translation: Protein synthesis in prokaryotes and eukaryotes; translational regulation; post-translational modifications.

Genetic Code: Organization, properties, degeneracy, universality, wobble hypothesis and codon usage bias.

Regulation of Gene Expression in Prokaryotes: Operon concept; lac, trp, and ara operons; bacteriophage λ lytic–lysogenic regulatory switch.

Regulation of Gene Expression in Eukaryotes: Chromatin-mediated regulation; cis-regulatory elements; transcription factors; enhancers, silencers, insulators; epigenetic regulation; post-transcriptional and translational control mechanisms.

Cell Biology

Cell Cycle Regulation: Cell cycle checkpoint; role of RB, E2F and p53 in tumour suppression; Membrane Transport of Small Molecules: Principles of membrane transport, membrane transport, proteins, active and passive membrane transport, ionophores.

Intracellular Compartments and Protein Sorting: Compartmentalization of higher cells; signal peptides and signal patches; transport of proteins into nucleus, mitochondria and chloroplasts.

Vesicular Traffic in the Secretory and Endocytic Pathways: Transport of proteins from E.R. through the Golgi apparatus; role of mannose 6-phosphate receptor in lysosomal enzyme sorting;

transport from the plasma membrane via endosomes-endocytosis; transport from the trans Golgi network to the cell surface-exocytosis.

Cell Signalling: Principles of cell signalling; cell surface and intracellular receptor proteins; signalling via G-protein linked cell surface receptors; inositol phospholipid pathway, calmodulin.

Apoptosis: Concept and significance of programmed cell death; intrinsic (mitochondrial) and extrinsic (death receptor-mediated) apoptotic pathways; caspases and Bcl-2 family proteins; regulation of apoptosis; apoptotic body formation; physiological and pathological significance of apoptosis.

BOT2PDSE02T

(ii) APPLIED PLANT BREEDING AND PLANT TISSUE CULTURE (50 marks)

Course outcome: After successful completion of the course, students will be able to:

- Explain the principles and methods of conventional and modern plant breeding.
- Apply molecular breeding approaches for crop improvement.
- Understand the scientific basis and applications of plant tissue culture.
- Evaluate in vitro technologies for conservation, propagation, and genetic improvement of plants.
- Interpret recent advances in genome editing and plant biotechnology for sustainable agriculture.

Course details:

Plant Genetic Resources and Principles of Plant Breeding

Plant genetic resources: Origin, evolution and domestication of crop plants; centres of origin and diversity; germplasm exploration, collection, characterization, evaluation, conservation and utilization; genetic basis and objectives of plant breeding; modes of reproduction and pollination; breeding methods for self-, cross- and vegetatively propagated crops; selection methods; hybridization techniques; heterosis and inbreeding depression; male sterility and self-incompatibility; mutation breeding and polyploidy breeding.

Crop Improvement and Molecular Plant Breeding: Conventional and modern approaches to crop improvement: Population improvement methods; hybrid breeding; quantitative genetics in plant breeding; marker-assisted selection (MAS); marker-assisted backcross breeding (MABB); quantitative trait loci (QTL) mapping; genomic selection; genome-wide association studies (GWAS); breeding for resistance to biotic and abiotic stresses; biofortification; speed breeding; genome editing and precision breeding using CRISPR-Cas systems.

Plant Tissue Culture and *In Vitro* Regeneration

Concept of cellular totipotency and morphogenesis: Organization of plant tissue culture laboratory; aseptic techniques; culture media and plant growth regulators; explant selection and surface sterilization; callus culture; cell suspension culture; organogenesis; somatic embryogenesis; micropropagation; synthetic seed technology; factors affecting in vitro morphogenesis and regeneration; hardening and acclimatization of regenerated plants.

Advanced Plant Tissue Culture and *In Vitro* Technologies

Tissue Culture Technologies: Meristem, shoot-tip and nodal culture; production of virus-free plants; anther, pollen and ovule culture; haploid and doubled haploid production; embryo culture and embryo rescue; endosperm culture; protoplast isolation, culture and fusion; somatic hybridization and cybridization; somaclonal variation; in vitro mutagenesis; secondary metabolite production; cryopreservation and in vitro conservation of germplasm.

Biotechnological Applications in Plant Breeding

Plant genetic transformation: *Agrobacterium*-mediated and direct gene transfer methods; molecular markers and DNA fingerprinting in crop improvement; functional genomics and molecular breeding; transgenic crops and biosafety; genome editing for crop improvement; plant breeding for climate resilience, sustainable agriculture and nutritional security; commercial applications of plant tissue culture; seed production and certification.

Suggested readings:

1. Concepts of Genetics- Klug W.S., Cummings M.R., Spencer C.A. & Palladino M.A. (Pearson International Edition)
2. Essential Genetics- A Genomic Perspective- Hartland D.L. & Elizabeth W.J. (Jones & Bartlett publishers)
3. Genes IX- Lewin Benjamin (Jones & Bartlett publishers)
4. Genetics- A Conceptual Approach- Pierce B. (W.H. Freeman & Co.)
5. Genetics- Analysis of genes and genomes- Hartland D.L. & Elizabeth W.J. (Jones & Bartlett publishers)
6. Genetics- from genes to genomes- Hartwell (Tata McGraw-Hill Int. Edition)
7. Genetics- A Molecular Approach- Peter J. Russell (Pearson Int. Edition)
8. Molecular Cell Biology- Lodish H, Berk A, Kaiser C.A., Krieger M., Scott M.P., Bretscher A., Ploegh H. &Matsudaira P. (W.H. Freeman & Co.)
9. Principles of Gene Manipulation & Genomics- Primose S.B. &Twyman R.M. (Blackwell publishing)
10. Principles of Genetics- Snustad D.P. & Simmons M.J. (John Wiley & sons Inc.)
11. Principles of Genetics- Tamarin R.H. (Tata McGraw-Hill edition)
12. Molecular Cell Biology, Lodish, Harvey; Berk, Arnold; Zipursky, S. Lawrence; Matsudaira, Paul; Baltimore, David; Darnell, J. E. New York: W.H. Freeman & Co.
13. Cell And Molecular Biology: Karp Gerald, Cbs Publisher & Distributor.
14. The Cell - A Molecular Approach, Cooper, Geoffrey M. Sunderland (MA): Sinauer Associates, Inc.
15. Molecular Biology of the Cell, Alberts, Bruce; Johnson, Alexander; Lewis, Julian; Raff, Martin; Roberts, Keith; Walter, Peter New York and London: Garland Science.
16. Cell and Molecular Biology: De Robertis, E.D.P. and De Robertis Jr, E.M.F. 2001.
17. Biochemistry & Molecular Biology Of Plants, Russell L. Jones, Wilhelm Gruissem, Bob B. Buchanan, John Wiley & Sons.
18. Lehninger principles of Biochemistry, Albert L. Lehninger, David Lee Nelson, Michael M. Cox, W.H. Freeman
19. Bhojwani, S.S. and Razdan, M.K. 1996. Plant Tissue Culture: Theory and Practice (a revised edition). Elsevier Science Publishers, New York, USA.
20. Bojwani, S.S. 1990. Plant Tissue Culture: Applications and Limitations, Elsevier Science Publisher, New York, USA.
21. Collins, H.A. and Edwards, S. 1998. Plant Cell Culture, Bios Scientific Publishers, Oxford, UK.
22. George E.F., Hall M.A. and Klerk J.D. Plant Propagation by Tissue Culture (3rd Ed.), Springer
23. Khasim, S.M. 2002. Botanical Microtechnique: Principles and Practice, Capital Publishing Company, New Delhi.

24. Vasil, I.K. and Thorpe, T.A. 1994. Plant Cell and Tissue Culture, Kluwer Academic Press, The Netherlands.
25. Principles of Plant Breeding, Allard R.W., John Wiley & Sons.
26. Plant Breeding, PoehlmanJ.M. &Barthakur D., Oxford & IBH.
27. Plant Breeding- Principles and Methods, Singh B.D. Kalyani Publishers.
28. Principles and Practice of Plant Breeding, Sharma J.R., Tata McGraw Hill.
29. An Introduction to Plant Breeding, Jack Brown, Peter Caligari, WileyBlackwell
30. Molecular Marker Systems in Plant Breeding and Crop Improvement, Lörz, Horst; Wenzel, Gerhard (Eds.), Springer.
31. Biostatistical analysis, Zar JH. Englewood Cliffs, NJ. Prentice
32. Basic Biostatistics and its Application. Animesh K. Datta. New Central Book Agency (P)

Combination 3

BOT2PDSE01T

(i) ADVANCED PLANT PHYSIOLOGY& BIOCHEMISTRY (50 marks)

Course outcome: This course will expose the students to advanced areas of plant physiology and biochemistry. This will enhance the knowledge of the students who are interested to pursue further research in this arena. This is an elective course and students are free to choose the course based on their admiration to the specific subject area.

Course details:

Molecular basis of plant stress physiology: Types of environmental stresses; Plant responses to osmotic adjustment: Compatible solutes and their biosynthetic pathways like free prolines, glycine betaines, sugar alcohols, raffinose family oligosaccharides (RFOs); SOS1, SOS2 & SOS3 pathways during salinity stress; Heat shock proteins during heat stress; LEA and other antifreeze proteins during freezing stress; Overlapping transcriptional regulatory networks in plant responses to osmotic, heat, and cold stress: ABA-dependent and ABA-independent pathways, roles of ABRE, coupling element (CE), AREB/ABF, MYC2, MYB2, DRE/CRT, CBF/DREB1, DREB2 transcription factors; Cellular signal transduction cascades in response to high salinity and water deficit: Proposed model of early ABA-mediated processes; Molecular basis of freezing stress tolerance, Freezing-induced lesions associated with the plasma membrane in isolated protoplasts; Flooding stress, oxygen deficit, molecular basis of escape strategy and quiescent strategy of rice during flooding, cross-talk of Ethylene, ABA and GA; Oxidative stress: model of the ROS signal transduction pathway inclusive of ROS-scavenging and ROS-producing pathways; Molecular basis of heavy metal stress and phytoremediation pathways; Relevant Cross-talk in stress responses.

Genomics and Transcriptomics: DNA sequencing by Sanger's method, physical mapping, whole genome shotgun sequencing, BAC/YAC library, genome annotation at different levels; Genome sequencing and Transcription profiling strategies and programs: Current scenario; New technologies for high-throughput sequencing, methods for sequence alignment and gene annotation; Approaches to analyze differential expression of genes - ESTs, SAGE, microarrays, RNA-sequencing and their applications; Gene tagging, gene and promoter trapping, knockout and knock-down mutants; RNA interference and its application; Major Epigenetic mechanisms of gene expression regulation.

Proteomics: Comparative account of translation in prokaryotes and eukaryotes; Post translational modifications; Use of vectors for overexpression of proteins; Protein extraction/purification techniques viz., 1-D and 2-D gel electrophoresis for proteome analysis,

Sample preparation, Gel resolution and staining, Column chromatography, Mass spectrometry-based method for protein identification like MALDITOF, PMF (protein mass fingerprinting) and LCMS; Future directions in proteomics: Scope of functional proteomics, its relevance/significance in the post genomic era; Proteomics as a tool for plant genetics, breeding and diversity studies.

Secondary metabolites and their biotechnological aspects: Natural products (secondary metabolites), their range and ecophysiological functions; Overview of terpenoidal, alkaloidal, and phenolic metabolites and their biosynthesis; Molecular approaches and biotechnological applications; Metabolic engineering in the production of pharmaceuticals.

Suggested Readings:

1. Introduction to Plant Physiology: William G. Hopkins and Norman P.A. Huner. (Fourth Edition) 2008. John Wiley& Sons, Inc.

2. Biochemistry and Molecular Biology of Plants, 2nd Edition

Bob B. Buchanan (Editor), Wilhelm Gruissem (Editor), Russell L. Jones (Editor)

ISBN: 978-0-470-71421-8. July 2015**.**

3. Lehninger Principles of Biochemistry: David L. Nelson and Michael M. Cox.(Fifth edition) 2009. W. H. Freeman publication.

4. Biochemistry: Jeremy M. Berg, John L. Tymoczko, Lubert Stryer. (Fifth edition). 2002. W.H. Freeman publication.

5. Plant Physiology and Development:

By Lincoln Taiz, Ian Max Møller, Angus S. Murphy, Eduardo Zeiger, 2023, Sinauer Associates (7th Edition)

Related review articles in the following Journals:

_ Annual Review of Plant Biology
_ Critical Reviews in Plant Science
_ Current Opinion in Plant Biology
_ Trends in Plant Science
_ Plant Physiology, Plant Cell
_ Annual Review of Plant molecular biology
_ Annual Review of Plant Physiology,
_ Plant Molecular Biology

BOT2PDSE02T
(ii) PLANT MOLECULAR BIOLOGY (50 marks)

Course outcome:

This course covers the important area of plant molecular biology, which has not been addressed in detail in any previous course. This is a very relevant course and teaches the students about major areas of plant biotechnology like recombinant DNA technology, gene cloning, gene sequencing, genome projects, cloning vectors, proteomics, RNA interference, gene regulation, epigenetics, etc. in a very concise and simplistic manner. This course is designed to help students greatly in answering CSIR/UGC NET questions.

Course details:

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., and *in planta* 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.

Applications of transgenic technology in plants: Transgenic crops for resistance against biotic and abiotic stresses; Engineering crops for male sterility and modification of flower colour, flowering, fruit ripening and senescence; GM crops for nutritional quality and quantity; RNAi- mediated crop improvement; Molecular farming; Metabolic engineering and hairy root culture for secondary plant products; Other applications; Global status and biosafety of transgenic plants.

Genome Editing Technology in plants: Homologous recombination (HR) of double-strand-break repair or HDR (homology directed repair); Non-homologous end-joining pathways of double-strand-break repair; Types of Genome Editing Technologies: SSN (Sequence specific nucleases) systems like zinc finger nucleases (ZFNs), the transcription activator-like effector nucleases (TALENs), and the clustered regularly interspaced short palindromic repeats/CRISPR-associated protein 9 (CRISPR/Cas9) system; Mechanisms of the CRISPR/Cas9-based genome editing in plants and its difference from transgenic technology; Pipeline of CRISPR/Cas9-based Genetic Transformation of plants from Gene Selection to Plant Analysis; Application of Genome-Editing in Crop improvement programs; Biosafety concerns about Genome-Edited plants; SDN-1, SDN-2 and SDN-3 categorisation in India; Global and Indian status of Genome-Edited plants versus Genetically Engineered plants.

RNAi Biology and its applications: Discovery of RNA interference; Categories of small non-coding RNAs-dsRNA, siRNA, shRNA, piRNA, miRNA; Mechanism of RNAi; Expression of dsRNA in animals and plants and its applications; Analysis of expression of dsRNA and gene silencing, use of RNAi in the prevention of diseases in animal models and crop improvement; RNAi therapy.

Gene regulation: Regulation of prokaryotic gene expression (lac, his, trp, ara operons and catabolite repression); Regulation of gene expression in eukaryotes (in Yeast *Gal* gene), transcriptional control (changes in chromatin structure, epigenetic control, transcription factors), epigenetic gene regulation (DNA methylation, histone modifications, epigenetic control of transposons and repetitive elements, imprinted genes); methods for analyzing epigenetic marks (post transcriptional regulation, regulation of translation and post translational modification); RNA-mediated control of gene regulation; Heterochromatin in gene silencing.

Recombinant DNA technology and analytical methods: Isolation and purification of RNA, DNA (genomic and plasmid), analysis of RNA, DNA restriction and nucleic acid modifying enzymes, restriction mapping; Basics of Cloning: Various ways of cloning, Cloning into different vectors/ plasmids, phages and phage derived PAC, BACs and YAC, selection and screening of clones; Methods of DNA, RNA and protein analysis: Electrophoretic techniques, Southern and Northern blotting, preparation of probes; RFLP, AFLP, DNA finger-printing, foot-printing and its application; Native PAGE, SDS-PAGE, 2-D PAGE, Isoelectric focusing of gels; Western blotting, chemiluminescence, ELISA; Overexpression of Recombinant proteins: over expression and tagging of proteins in *E. coli* as well as in eukaryotic systems; Gel retardation assays, Yeast one, two and three hybrids assays.

Suggested Readings:

1. Biochemistry & Molecular Biology of Plants: Bob B. Buchanan, Wilhelm Gruissem, and Russell L. Jones. 2015. ASPP publication
2. Lehninger Principles of Biochemistry: David L. Nelson and Michael M. Cox.(Fifth edition) 2009. W. H. Freeman publication.

3. Molecular Biology and Genomics: Cornel Mulhardt. 2007. ELSEVIER
4. Introduction to Genetic Analysis: Griffiths, Wessler, Lewontin, Carroll. (Ninth Edition) 2008. W.H. Freeman and Company
5. Plant Cell and Tissue Culture: Indra K. Vasil and Trevor A. Thorpe. Kluwer Academic Publishers Group (1994)
6. Principles of Gene Manipulation and Genomics: S.B. Primrose and R.M. Twyman.(Seventh edition) 2008. Blackwell Publishing
7. Related review articles in the following Journals:
Annual Review of Plant Biology, Critical Reviews in Plant Science, Current Opinion in Plant Biology, Trends in Plant Science, Plant Physiology, Plant Cell, Annual Review of Plant molecular biology, Annual Review of Plant Physiology, Plant Molecular Biology

Combination 4

BOT2PDSE01T

i) ANGIOSPERMS TAXONOMY AND BIOSYSTEMATICS (50 marks)

Course outcome: This course is intended to prepare students for classical and advanced topics related to their DSE choices. Upon completion of this course, the student's skill set will be substantially enhanced, enabling them to pursue a career in higher education and research. This course will focus on presenting an overall understanding and strengthening their research and teaching abilities. As scientific communication is an essential component of scientific research, major emphasis has been placed on this aspect.

Course Details:

Historical background of Plant taxonomy: Renowned taxonomists and their Major Contributions, Development of plant taxonomy in India. Activities of the Botanical Survey of India (BSI) in relation to taxonomic studies and conservation. Activities of the Botanical Survey of India (BSI)

International Code of Nomenclature (ICN): Background of International Botanical Congress and nomenclatural codes; Important developments in rules of nomenclature in different codes, the latest changes, additions, and alterations in ICN; Valid Publication: provision of new taxa.

Developmental phases of plant taxonomy: Classification of Hutchinson, including dicta of angiosperms evolutionary characters; Bessey's system of classification; Objectives and an overview of APG classification, ANA grade, outline of APG classification IV (2016).

Taxonomic literature and aid in identification: Floras, manuals, monographs and revisions; Computer applications for identification of plants: websites, e- Flora, e-catalogue, e-index, GBIF, BHL, WCSP, POWO, Jstor-Global Plants, virtual herbaria, Index Herborum.

Taxonomic data sources: Contributions to seedling morphology, palynology, embryology, cytology, and sieve element plastids in taxonomy.

Biosystematics: Concept and objectives; biosystematics categories, steps and methods of biosystematics studies; Turesson's experiment.

Recent trends of Chemotaxonomy and Numerical taxonomy: Principles of cladistics: Concepts & Definitions (Phylogeny, ontogeny, monophyly, paraphyly, polyphyly, apomorphies and synapomorphies), Molecular phylogenies and the diversification of angiosperms.

Species concept and speciation: Different species concepts: Biological Species Concept (BSC), Evolutionary Species Concept (ESC), Phylogenetic Species Concept (PSC), Recognition Species Concept, Taxonomic Species Concept (TSC); Speciation-variation and source of variation in

plant population, reproductive isolation barriers, speciation types- allopatric, sympatric, parapatric and genetic view of speciation.

Plant Molecular Systematics: Plant genomes (nuclear, mitochondrial & chloroplast); Generating molecular data (restriction site mapping, gene sequencing); Sequence alignment, Phylogenetic analysis (parsimony, Maximum Likelihood, Bayesian approaches, Neighbor-Joining); Concept of DNA barcoding, standard barcode markers (nrDNA, cpDNA and mtDNA); Phylogenomic approach towards understanding plant systematics; Molecular divergence and molecular models, biological variations and molecular models.

Suggested Readings:

1. Angiosperm Phylogeny Group (2016). An update of the Angiosperm Phylogeny Group
2. Classification for the orders and families of flowering plants: APG IV. Botanical Journal of the Linnaean Society 181: 1-20.
3. Crawford, D.J. (2003). Plant Molecular Systematics. Cambridge University Press, Cambridge, UK.
4. Cronquist, A. (1981). An Integrated System of Classification of Flowering Plants. Columbia University Press, New York.
5. Davis, P. H. and Heywood, V. H. 1963. Principles of Angiosperm Taxonomy. Princeton, NJ: Van Nostrand
6. Henry, A.N., Chandrabose, M. (1980). An Aid to International Code of Botanical Nomenclature. Todat & Tomorrow's Printers and Publishers.
7. Hollingsworth, P.M., Bateman, R.M. and Gornall, R.J. (1999). Molecular Systematics and Plant Evolution. Taylor and Francis, London.
8. Judd. W.S., Campbell, C.S., Kellogg, E.A., Stevens, P.A. and Donoghue, M.J. (2002). Plant Systematics: A Phylogenetic Approach. Sinauer Associaes, Inc., Massachusetts.
9. Naik, V. N. 1984. Taxonomy of Angiosperms. Tata McGraw-Hill Publishing Company Limited, New Delhi.
10. Paria, N.D. (2022). Plant Taxonomy and Biodiversity. Santra Publication Pvt. Ltd.
11. Patané, J.S.L., Martins, J. and Setubal, J.C. (2018). Phylogenomics.
12. Radford, A. E. 1986. Fundamentals of Plant Systematics.Harper & Row, London.
13. Stadler P. (eds) Comparative Genomics. Methods in Molecular Biology, vol 1704. Humana Press, New York, NY.
14. Soltis, P., and Doyle, J. J. (2012). Molecular Systematics of Plants II: DNA sequencing. Springer Science & Business Media.
15. Simpson, M. G. 2010. Plant Systematics. Elsevier Academic Press, Amsterdam.
16. Stuessy, T.F. (2008). Plant Taxonomy: The systematic Evaluation of Comparative Data. Columbia University Press, New York.
17. Singh, G. 1999. Plant Systematics- Theory and Practice. Oxford and IBH Publishing Co. Pvt Ltd., New Delhi.
18. Sivarajan, V. V. (1990). Introduction to Principles of Plant Taxonomy. Oxford & IBH.
19. Taylor, D. V. and L. J. Hickey 1997. Flowering Plants: Origin, Evolution and
20. Phylogeny. CBS Publishers & Distributers, New Delhi.

BOT2PDSE02T

PLANT ECOLOGY AND ENVIRONMENTAL BIOLOGY-II (50 marks)

Course Outcome: The syllabus covers both traditional and contemporary areas of ecology and environmental activities. The topics below intend to convey in-depth knowledge befitting the specialisation in the aforesaid course. Relevance of soil and fire studies on populations and communities, their models, energy in ecosystems, aquatic and terrestrial habitats, case studies in pollution and natural resource management, RS-GIS applications, and sustainable development and impact assessment have been included for overall understanding.

Course details:

Ecological factors and plant life: Light, soil properties and role on plant life; Water Relations and Thermal Energy Balance; Ecological levels of organisation; Concept of limiting factors; Law of tolerance and limiting factors, homeostasis and types of responses.

Ecosystem Processes: Primary Productivity-measures of terrestrial and aquatic ecosystems; Estimation of NPP Using Remote Sensing and Eddy Covariance Methods.

Niche: concepts, characteristics, niche responses; Resource Partitioning and character displacement; Tilman's model for inter-specific competition for differential resource utilization.

Population studies: Characteristics: Strategies-ruderal, competitive, stress-tolerance; Alien species-invasive process, characters, impact and control measure; inter and intra specific regulation, life table.

Communities and species interactions: concepts of community nature; Classification of plant communities and hierarchical units of vegetation.

Different types of Competition and Other Interactions: Lotka-Volterra model of species interaction; Biodiversity metrics; community stability and disturbance.

Concept of continuum and ordination: succession process; types and models; concept of climax, Dominance–diversity curves; Threats to biodiversity: species extinctions; IUCN threat categories, Red data book; Invasions: causes and impact; Biodiversity conservation, principles and strategies; *in-situ* and *ex-situ* conservation; Protected Area Network; Biodiversity Hot spots: concepts, distribution and importance.

Landscape ecology: Ecotones and edge types and development; corridors; theory of island biogeography; Important terrestrial and aquatic ecosystems and their characteristics; ecological zonation; thermal stratification.

Ecosystem energetics: Production (primary and secondary); Biomass and Turnover (Terrestrial and aquatic); Energy flow models; Grazing and Detritus pathway; Ecological efficiencies and energy budget.

Environmental Management and Sustainable Development: Concepts; Strategies; Threats; Environment Sustainability Index (ESI); Ecological Foot Prints

Global Environmental Change: Issues of Global Environmental Change; Stratospheric ozone layer depletion-Causes of and consequences; Effects of enhanced UV-B on plants; Greenhouse effects; Greenhouse gases and their sources; Implications on environment; International efforts on climate change issues; Causes and consequences of excessive atmospheric deposition of nutrients and trace elements; Eutrophication; Acid rain and its effect on plants and ecosystems.

Environmental Pollution: Air pollution-sources and effects of SO_2, NO_2, O_3, HF, photochemical smog and particulates on plants and human health; aeroallergens and allergies; Noise pollution: Types, sources and effects on human health; Water Pollution: Types and sources;

Effects on water quality, plants and human health; Soil pollution: Types and sources, Effects of pesticides and heavy metals on ecosystems, mechanisms of metal toxicity, metallophytes; Uptake, bioaccumulation, bio-transformation and excretion of xenobiotics; National Environment policy; National air monitoring programme; Biological abatement of air pollution, scope of green belt development, phytoremediation.

Remote Sensing and GIS: General Mechanism of Remote Sensing Data Recording; General Characteristics of Remote Sensors and Remote Sensing Platforms; Remote Sensing Satellites and Sensors. Spectral Remote Sensing Applications in Environmental Studies; GIS Data - Concepts and Components; Conceptual and Logical Data Modelling; Applications of GIS.

Suggested Readings:

1. M.G.Barbour et al. (1999): Terrestrial Plant Ecology; Edition Weiley Longman Inc., California
2. N.C.Bradly (1990): The nature and properties of soil. Macmillan Press. NY.
3. D. Menllen-Dombois and H. Ellenberg(1974): Aims and Methods of Vegetation Ecology. Wiley ,N.Y.
4. R.E.Ricklefs and G.L.Miller (2000) Ecology. W.H.Frceman and Co., N.Y.
5. C.R.Townsend et al. (2003): Essentials of Ecology. Blackwell publ., Oxford.
6. R.L.Smith (1996) : Ecology and Field Biology. Harper Collins College Publ., Inc., N.Y.
7. A.M.Chandra and S.K. Ghosh: Remote Sensing and Geographic Information System. Narosa, New Delhi.
8. E.P. Odum and G.W. Barrett. 2005. Fundamentals of Ecology. Cengage Learning India Pvt. Ltd.
9. J.S. Singh, S.P. Singh and S.R. Gupta. 2008. Ecology, Environment & Resource Conservation. Anamaya Publications. ESM - 102:
10. Dobson, M. and Frid, C. 1998. Ecology of Aquatic Systems.
11. Adams, S.M. (Ed). 2002. Biological Indicators of Aquatic Ecosystem Stress. American Fisheries Society, Bethesda.
12. Talling, J.F. and Lemoalle, J. 1998. Ecological Dynamics of Topical Inland Waters. Cambridge University Press.
13. Wetzel, R.G. 2000. Limnology: Lake and River Ecosystems. Academic Press.
14. Anne E. Magurran. 2003. Ecological diversity and its measurements. Blackwell Publications.
15. J.S.Singh, S.P. Singh and S.R. Gupta. 2008. Ecology, Environment and Resource Conservation. Anamaya Publications (New Delhi).
16. V.H. Heywood and Watson R.T. (Ed). 1995. Global Biodiversity Assessment: UNEP. Cambridge University Press. ESM – 202:
17. K. De. (3rd Ed). 2008 Environmental Chemistry. New Age Publications India Ltd.
18. S.C. Santra. 2011. Environmental Science. New Central Book Agency.
19. V.P. Kudesia. 1997. Air Pollution. Pragati Prakashan.
20. M.H. Rao and H.V.H. Rao. 1998. Air Pollution. Tata McGraw Hill Publication.
21. B.R. Gurjar, L. T. Molina and C. S. P. Ojha. 2010. Air Pollution. CRC Press.
22. I.L. Pepper, C.P. Gerba and M.L. Bresseau. 2006. Environment and Pollution Science. Academic Press. SEMESTER – IV ESM – 401.

BOT2PDSE03M
DISSERTATION-1 50 Marks

The dissertation will be a project work (experimental/review) for which a dissertation project must be submitted and will be assessed by external expert(s). The topic of choice will depend on the choices the students make across the pair combinations of BOT2PDSE01T & BOT2PDSE02T, and will be finalised in consultation with the concerned teacher/(s) teaching those papers.
The modalities of the Similarity check will be followed as per the resolutions of the Departmental Committee meeting regarding the Semester IV evaluation of dissertation projects prepared by the students.

N.B. Students can opt in consultation with the supervisor to do 2 separate / allied dissertation or one dissertation

BOT2PDSE04M
DISSERTATION-1I 50 Marks

The dissertation will be a project work (experimental/review) for which a dissertation project must be submitted and will be assessed by external expert(s). The topic of choice will depend on the choices the students make across the pair combinations of BOT2PDSE01T & BOT2PDSE02T, and will be finalised in consultation with the concerned teacher/(s) teaching those papers.
The modalities of the Similarity check will be followed as per the resolutions of the Departmental Committee meeting regarding the Semester IV evaluation of dissertation projects prepared by the students.

N.B.- Students can opt in consultation with the supervisor to do 2 separate / allied dissertation or one dissertation

BOT2PDSE05M
PRESENTATION 50 Marks

The presentation will be delivered (with the help of ICT tools) and will present the key findings/review of the dissertation work of **BOT2PDSE03M,** which will be assessed by an external expert on the day of the examination.

N.B: Presentation (BOT2PDSE05M) will combine with Both BOT2PDSE03M & BOT2PDSE04M

- **Marks break up for Dissertation-I and Dissertation-II Project work** (Course code **BOT2PDSE03M and BOT2PDSE04M and Seminar presentation** (Course code: **BOT2PDSE05M**)

- ***For Review based project/dissertation-I***

Sl. No.	*Topics*	*Marks distribution*	*Allotted total marks*
1	*Writing style, clarity of thought, as well as neat presentation (proper formatting, pagination, indexing, content description)*	*5*	*50*
2	*Literature review*	*17.5*	
3	*Hypothesis & rationality*	*5*	
4	*Bibliography*	*5*	
5	*Plagiarism/ Similarity check*	*7.5**	
6	*Interactions with the external expert/(s)*	*10*	

- ***For Experiment/Laboratory based project/dissertation-I***

Sl. No.	*Topics*	*Marks distribution*	*Allotted total marks*
1	*Experimental design, type, number of experiments performed, results obtained as well as neat presentation (proper formatting, pagination, indexing, content description)*	*17.5*	*50*
2	*Literature review*	*5*	
3	*Hypothesis & Rationality*	*5*	
4	*Bibliography*	*5*	
5	*Plagiarism/ Similarity check*	*7.5**	
6	*Interactions with the External expert/(s)*	*10*	

- ***For Review based project/dissertation-II***

Sl. No.	*Topics*	*Marks distribution*	*Allotted total marks*
1	*Writing style, clarity of thought, as well as neat presentation (proper formatting, pagination, indexing, content description)*	*5*	*50*

2	*Literature review*	*17.5*	
3	*Hypothesis & rationality*	*5*	
4	*Bibliography*	*5*	
5	*Plagiarism/ Similarity check*	*7.5**	
6	*Interactions with the external expert/(s)*	*10*	

- ***For Experiment/Laboratory based project/dissertation-II***

Sl. No.	*Topics*	*Marks distribution*	*Allotted total marks*
1	*Experimental design, type, number of experiments performed, results obtained as well as neat presentation (proper formatting, pagination, indexing, content description)*	*17.5*	*50*
2	*Literature review*	*5*	
3	*Hypothesis & Rationality*	*5*	
4	*Bibliography*	*5*	
5	*Plagiarism/ Similarity check*	*7.5**	
6	*Interactions with the External expert/(s)*	*10*	

- Semester IV, **Seminar presentation** (Course code **BOT2PDSE04M**) shall have the following marks distribution

Sl. No.	Topics	Marks distribution	Total Marks
1	Technical depth and content of the presentation.	20	50
2	Presentation ability/skill	20	
3	Interaction with external expert/(s)	10	

- The Departmental papers Dissertation Project work (Course code BOT2PDSE03M and Seminar presentation (Course code: BOT2PDSE04M) having 100 and 50 marks respectively, shall be evaluated by the External Expert/(s).

- The soft copy of the Dissertation must be checked for Plagiarism/Similarity % with Turnitin software using the usual filters of 14 consecutive words and to also exclude the bibliography, title page and figures before binding and final submission.
- *The respective supervisor of projects will check the similarity percentage on Turnitin for the students. A maximum of two checks per student will be allowed, a draft check and a final check.
- Dissertations having 10% similarity or less will be awarded the full 7.5 marks. For similarities between 11 and 15%, 5 marks will be awarded and for 16% to 19 %, 2.5 marks will be awarded. Dissertations having more than 19%, will not be accepted and the student will have to take the responsibility to reduce the similarity to either below 10 % or in between 10-19%. If in the final submission, similarity higher than 19% persists, the student will be penalised as per the extant UGC regulations without any exceptions. The hard copy of the final dissertation must contain a similarity certificate to be given by the concerned supervisor based on the Turnitin generated similarity percentage and also a supervisor's certificate attesting to the originality of the work undertaken by the candidate The dissertation is to be presented both as a hard copy and a soft copy (in pdf for archival purposes in the respective department). This final copy is then to be submitted for the examination.

BOT2PDSE06P

LABORATORY COURSE **50 Marks**

Experimental hands-on training based on the theoretical syllabi of electives and their combinations of courses BOT2PDSE01T and BOT2PDSE02T