R-917
13.8.2026

Secretary

UNIVERSITY OF CALCUTTA

Notification No. CSR/93/2026

It is notified for information of all concerned that in terms of the provisions of Section 54 of the Calcutta University Act, 1979, (as amended), and, in the exercise of his powers under 9(6) of the said Act, the Vice-Chancellor has, by an order dated 05.08.2026, approved the Syllabus of 2-year (Four Semester) M.Sc. Syllabus for the Course of Study in Botany , under NEP guidelines, as laid down in the accompanying pamphlet.

The above syllabus shall take effect from the academic session 2026-2027 and onwards.

12.08.2026

Prof.(Dr.) Debasis Das

Registrar

SENATE HOUSE

Kolkata-700073

12.08.2026

Course Structure-
2 Yr
Detailed M.Sc. Syllabus
(NEP 2020)
In Botany
University of Calcutta
2026

following

Post Graduate Regulations, 2026

under

National Education Policy 2020 (NEP 2020)/ State Education Policy 2023 (SEP 2023) vide CSR/59/2026 dated 17.04.2026.

Programme Educational Objectives (PEOs)

Programme Educational Objectives	Specific Objectives
1. Advanced Disciplinary Knowledge	1.1Comprehensive knowledge of plant sciences, microbiology, mycology, genetics, molecular biology, biotechnology, bioinformatics, immunology, and allied life sciences. 1.2. Enable students to understand biological systems from molecular to ecosystem levels.
2. Research and Innovation	Equip students with theoretical, practical, analytical, and computational skills to design, conduct, interpret, and communicate high-quality research using modern approaches
3. Biotechnology and Translational Applications	Enable students to apply knowledge of biotechnology, genetic engineering, tissue culture, genomics, bioactive compounds, microbial technology, and molecular breeding for agriculture, healthcare, industry, and environmental sustainability.
4. Indigenous Knowledge and Sustainable Practices	Encourage understanding and scientific validation of Indigenous Knowledge Systems (IKS), traditional medicinal practices, sustainable agriculture, biodiversity conservation, and their integration with modern biological sciences.
5. Problem Solving and Sustainable Development	Develop the ability to analyze biological problems and design innovative, sustainable solutions related to crop improvement, disease management, environmental conservation, climate resilience, food security, and human welfare.
6. Digital and Technological Competence	Foster proficiency in bioinformatics, computational biology, genome analysis, molecular systematics, data management, artificial intelligence-assisted biological research, and emerging life science technologies.
7. Leadership, Communication, and Entrepreneurship	Develop leadership qualities, teamwork, scientific communication, innovation, entrepreneurship, and translational research skills for careers in academia, industry, government, healthcare, and biotechnology sectors.
8. Lifelong Learning and Global Competence	Cultivate critical thinking, adaptability, interdisciplinary learning, and lifelong professional development, enabling graduates to address emerging scientific challenges at national and global levels.

Orientation of courses in four semesters in MSc Botany

2 Year Program

1st Semester			
Paper Code	**Paper Name**	**Marks**	**Credit**
BOT 411	Evolutionary Botany	40	3
BOT 412	Applied Microbiology	40	3
BOT 413	Mycota	40	3
BOT 414	Plant Disease Biology	40	3
BOT 415	Indigenous Knowledge System of Plant Science	20	2
BOT 416	Combined Practical Paper 1	70	6
	Total	**250**	**20**
2nd Semester			
Paper	**Paper Name**	**Marks**	**Credit**
BOT 421	Plant Systematics and Biodiversity	40	3
BOT 422	Cell Biology	40	3
BOT 423	Phytochemistry	40	3
BOT 424	Genetics and Genomics	40	3
BOT 425	Research Methodology	20	2
BOT 426	Combined Practical Paper 2	70	6
	Total	250	**20**
3rd Semester			
Paper	**Paper Name**	**Marks**	**Credit**
BOT 511	MOOCS & SWAYAM	50	4
BOT 512	Biostatistics, Bioinformatics and Artificial Intelligence in Plant Sciences	40	3
BOT 513	Specialisation (Elective)*	20+20	2+2
BOT 514	Biochemistry and Developmental Physiology	40	3
BOT 515	Plant Biotechnology	40	3
BOT 516	Combined Practical Paper 3	40	3
	Total	**250**	**20**
4th Semester			
Paper	**Paper Name**	**Marks**	**Credit**
BOT 521	Dissertation	150	12
BOT 522	Grant Writing	50	4
BOT 523	Review Writing	50	4
	Total	**250**	**20**

Total Marks: 1000 marks **Total Credit: 80**

Specialisation (Elective) (BOT 513)*

Paper Code	Paper Name
513A	Advanced Palaeobotany and Palynology
513B	Advanced Phycology
513C	Analytical Techniques
513D	Applied Virology
513E	Bryophytes
513F	Cell Fate and Dynamics
513G	Chemistry and Biology of Plant Natural Products
513H	Fungal Molecular Systematics
513I	Genetic and Epigenetic Perspectives of Plant Development
513J	Immunology
513K	Molecular Biology of Plants
513L	Molecular Stress Biology
513M	Taxonomy and Biosystematics
513N	Translational Plant Genetics and Cytogenetic Technologies

*** Select any *two* specialisation courses from the list (2 credits each paper)**

1st Semester

BOT 411

Evolutionary Botany

Total Marks- 40; Credit-3; Class 45 hours

Course Outcomes (COs)

I. Understanding

- The origin, evolution, and diversification of land plants and major evolutionary trends in the plant kingdom.
- Evolutionary advancements among bryophytes, pteridophytes, gymnosperms, and angiosperms.
- Evolutionary theories, prebiotic environments, origin of life, and the earliest evidence of life, including stromatolites, and correlate biological evolution with geological events.

II. Memorizing

- The morphology, anatomy, reproduction, life cycles, and classification of bryophytes, pteridophytes, and gymnosperms.
- The ecological, economic, and conservation importance of bryophytes, pteridophytes, and gymnosperms.
- The principles of taphonomy, geochronology, continental drift, and plate tectonics are evaluated to determine their significance for interpreting plant evolution and Earth's geological history.

III. Applying

- Scientific methods and botanical knowledge to identify representative taxa and interpret evolutionary patterns.
- Botanical concepts to address issues related to biodiversity, conservation, and ecosystem management.
- Ancient DNA, fossil biomolecules, and fossil fuel studies in reconstructing evolutionary history, palaeo environments, and depositional systems.

Programme Outcomes (POs)

Upon completion of this course, students will be able to demonstrate comprehensive knowledge of plant diversity, evolution, structure, function, and classification. They can apply botanical concepts to address issues related to biodiversity, conservation, and ecosystem management. They will be able to interpret biological and geological evidence, formulate hypotheses, and critically evaluate scientific concepts using logical and evidence-based reasoning.

Syllabus

Section-A

Phycology: Algal Systematics and Evolution of major groups: Morpho-taxonomy to Poly-phasic approach (Most primitive Chlorophyll bearing organism: Cyanophyta/Cyanobacteria/Prokaryota-Desikachary 1959, Kommarek 2014; Most diversified green lineage close to land plant - Chlorophyta –- Smith 1950, Leliaert 2012)

Biodiversity and conservation of Algae: Algae of different habitat, importance of conservation, in-situ and ex-situ conservation. Algal bloom formation and its control. Phytoplankton dynamics (Nutrient uptake model)

Algae in human welfare – Nutraceuticals; Pharmaceuticals; Metabolic engineering of algae: Biohydrogen production and carotenoids synthesis; *Chlamydomonas reinhardtii* as model organism. Application of Multi-omics in algal resources for biotechnological application. Mariculture techniques of seaweeds.

Section-B

Bryophytes and Pteridophytes: Evolutionary diversification of land plants; Evidences for plant terrestrialization; Evolutionary trends in Bryophytes and transition from two-dimensional (2D) to three-dimensional (3D) growth; Transition from non-vascular to vascular; Major evolutionary innovations in Pteridophytes, including the evolution of vascular tissues, leaves (microphylls and megaphylls) and sporangia; Significance of fossil Pteridophytes in understanding the early evolution, and subsequent diversification of seed plants.

Section-C

Palaeobotany and Palynology: Taphonomy, geo-chronology; brief concepts on continental drift and plate tectonics; Evolutionary theories and plant fossil records; Prebiotic environments, origin of life: theory and biology; earlier records of life on earth, stromatolites: types, formation, significance.

Pre-ovules, hydrasperman reproduction; Evolution of closed-carpel; Origin and evolution of angiosperms: fossil evidence, nature and distribution of earliest angiosperms; Morphology and diversity of pre-pollen/pollen/phytoliths; Ancient DNA and other fossil biomolecules, fossil fuels: origin, depositional facies.

Section-D

Gymnosperms: Classification of Gymnosperm proposed by Kramer & Green (1990); Bhatnagar & Moitra (1996).

Chemosystematics; Pollination mechanism & Embryogeny, Karyology, Conservation, Forest Biotechnology; Phylogenetic success in Gymnosperms.

Practical

1. Algal Diversity study: (Freshwater) Cyanobacteria and Chlorophyta.
2. Identification of seaweeds from different divisions-Chlorophyta, Phaeophyta, Rhodophyta.
3. Demonstration of mass cultivation in photo bioreactor.
4. Workout on structural modifications in Marchantiales, Jungermanniales, Anthocerotales and Funariales (*depending on availability of the specimen*).
5. Study on the morphology of vegetative and reproductive structures in Lycopodiales, Gleicheniales, Schizaeales, Salviniales, Cyatheales and Polypodiales (*depending on availability of the specimen*).
6. Types of rocks, study of fossil types and modes of preservation.
7. Study of macerated samples of peat, lignite and coal. Qualitative and quantitative (using tally mark) study of spores/pollen grains and preparation of histograms and pollen diagrams, inference on floristic composition, environment of deposition and stratigraphic age of sediments.
8. Pollen analysis of honey.
9. Study on external morphology of the genera within the following orders: Cycadales, Ginkgogales, Coniferales, Taxales and Gnetales (*depending on availability of the specimen*).

Suggested Readings

1. Phycology(4thEd.)R.L.Lee,CambridgeUniversityPress,2008.

2. Algae-An introduction to Phycology-C VandenHoek, D GMann, H M Janes, Cambridge UniversityPress,1995.

3. Hand Book of Microalgal culture .Ed by A. Richmond. Blackwell PublishingHouse,2003

4.Algae-Anatomy , Biochemistry and biotechnology-.Barsanti&P.Gualtieri.Taylor&Francis,2006.

5. MolecularBiologyofCyanobacteria-DABryant.KluwerAcademicPublisher,1995.

6. Photosynthesis in Algae -W.D.Larkman,E.Douglass & JARaven,Kluwer AcademicPublishers.

7. An Introduction to Phytoplanktond :Diversity and Ecology. R.Pal and A.Choudhury,Springer

1. Eames, A.J. (1936).

8. *Morphology of Vascular plant-lower group* (Psilophytales to Filicales). Tata McGraw-Hill Book Company, New Delhi.

9. Gifford, E. M., & Foster, A. S. (1989). *Morphology and Evolution of Vascular Plants*. W.H. Freeman and Company, New York.

10. Goffinet, B., & Shaw, A. J. (2008). *Bryophyte Biology*. 2nd ed. Cambridge University Press, Cambridge.

11. Ranker, T.A. & Haufler, C.H. (2008). *Biology and Evolution of Ferns and Lycophytes.* Cambridge University Press, United Kingdom.

12. Stewart, W.N., & Rothwell, G.W. (1993). *Palaeobotany and the Evolution of Plants.* 2nd ed. Cambridge University Press, New York.

13. Taylor, E. L., Taylor, T. N., & Krings, M. (2009). Palaeobotany*: The biology and Evolution of Fossil plants.* 2nd ed. Academic Press, New York.

14. Vanderpoorten, A. & Goffinet, B. (2009). *Introduction to Bryophytes*. Cambridge University Press, New York.
15. Brasier, M.D. (2013) *Microfossils*. George Allen and Unwin, London, 2nd Edition. p. 193
16. Cleal, C. J., & Thomas, B.A. (1999). *Plant Fossils. The History of Land Vegetation*. Woodbridge Boydell Press, Woodbridge, VA. p.128
17. Kumar, R. (2011) *Fundamentals of Historical Geology and Stratigraphy of India*. New Age International Publishers. P.254
18. Jones, T.P., & Rowe, N.P. (1999). *Fossil Plants and Spores: modern techniques*. The Geological Society, London. p. 396
19. Moore, P.D., Webb, J.A., Collinson, M.E. (1991) *Pollen Analysis*. 2nd Edition. Oxford (Blackwell Scientific Publications), p.216
20. Surange, K.R., Lakhanpal, R.N., Bharadwaj, D.C. (1974) *Aspects and Appraisal of Indian Palaeobotany*. Birbal Sahni Institute of Palaeobotany, Lucknow. p.674
21. Taylor, T.N., Taylor, EL, Krings, M. (2009) *Palaeobotany-The Biology and Evolution of Fossils Plants*. Elsevier. p. 1230
22. Willis, K. J., McElwain, J.C. (2002). *The Evolution of Plants*. Oxford University Press, New York, p. 378
23. Sporne, K. R. (1965). *The Morphology of Gymnosperms: The Structure and Evolution of Primitive Seed-Plants*. Hutchinson University Library. p 216
24. Coulter, J. M. & Chamberlain., C.J. (1917) *Morphology of Gymnosperms*. University of Chicago Press.
25. Bhatnagar, S. P., & Moitra, A. (1996) *Gymnosperms*. New Age International, New Delhi.
26. Kramer, K. U., & Kubitzki, K. (Eds.). (1990) *The families and genera of vascular plants. 1. Pteridophytes and gymnosperms*. Springer.
27. Pant, D. D. (2002) *An Introduction to Gymnosperms, Cycas and Cycadales*. Birbal Sahni Institute of Palaeobotany, Lucknow.
28. Chamberlain, C.J. (1935) *Gymnosperms: Structure and Evolution*, University of Chicago Press, Chicago. p 484

BOT 412

Applied Microbiology

Total Marks- 40; Credit-3; Class 45 hours

Course Outcomes (CO):

II. Understanding

- Microbial diversity, microbial interactions with humans, and the ecological, agricultural, environmental, and industrial significance of microorganisms.
- Bacterial structure, growth kinetics, differentiation, and factors influencing microbial growth and survival.

II. Memorizing

- Mechanisms of bacterial gene transfer, including conjugation, transformation, and transduction, and their significance in microbial evolution.
- The structure, function, and applications of plasmids, transposons, CRISPR-Cas systems, and bacterial gene regulation mechanisms.

III. Applying

- Recombinant DNA technology and microbial genetic tools for cloning, gene expression, and biotechnology applications.
- Microbiological and biotechnological principles to address challenges in medicine, agriculture, environmental sustainability, and industrial production.

Programme Outcomes (POs)

Upon completion of this course, students will be able to demonstrate comprehensive knowledge of microbiology, molecular genetics, biotechnology, immunology, and virology. They can analyze microbial systems and biological data to solve scientific and technological problems and perform microbiological, molecular biological, fermentation, and virological techniques with precision and safety.

Syllabus

Section-A

General Microbiology: I. Salient features of major bacterial groups: Archaea, Actinomycetes. Growth and differentiation: Measurement of growth, growth kinetics, batch, fed batch, continuous and synchronous growth. II. Bacterial cell wall ultra-structure and synthesis. III. Chemotherapy: Physical and chemical methods. Principles of chemotherapy, general mode of action of various chemotherapeutic agents: Sulfa drugs, antibiotics- classification and mode of action. IV. Antibiotic resistance, vaccines and antivirals.

Section-B

Bacterial Genetics: I. Bacterial Genetics: Conjugation: molecular mechanism of gene transfer and regulation. Transformation: Natural and artificial transformation and competence. Transduction: Generalized and specialized transduction. II. Plasmids: types, function and application. III. Bacterial Gene regulation: Positive and negative gene regulation and attenuation, lac, gal, trp, and Ara operons and their applications. Genetic switches. Quorum sensing. IV. Transposons: Types of bacterial transposons. Detection, regulation and molecular mechanism of transposition in bacteria. V. CRISPR-CAS evolutionary significance in bacterial innate immunity, mode of action and application. VI. Microbes and r-DNA Technology: Cloning and expression of recombinant genes.

Section-C

Microbial Biotechnology: I. Introduction to multidisciplinary nature of microbial biotechnology. Application of microbial biotechnology: in biopharmaceuticals (recombinant proteins, DNA vaccine, taxol), green chemistry (PLA, PHA); agriculture (thuricide); and environment (biosensors, bioremediation). II. Bioprocessing: bioprocess stages and units of operation, microorganisms used in biotechnology: sources, screening for productive strains and strain improvement, media formulation, and process optimization, growth linked and non-growth linked products Scale up. III. Fermenter and fermentation systems: Fermenter types, components, and operation. Submerged and solid-state fermentation; open and closed system of fermentation. IV. Downstream processing: removal of solids, filtration, centrifugation, foam separation, precipitation, cell disruptions, liquid-liquid extraction, chromatography, membrane processes. Drying and crystallization. Product certification and bioprocess economics.

Section-D

General Virology: I. Virus classification. II. Cultivation of viruses, methods for detection and quantification. III. Satellite virus, viroid, prions. IV. Bacteriophages genome organization. Genetic analysis of phages – complementation and recombination tests with phages. Phage therapy and typing. V. Plant virus: Tobacco mosaic virus genome organization, structure and replication. VI. Human Virus: HIV, SARS, HCV, Influenza genome organization, structure and replication.

Practical

1. Kinetics of amylase/invertase/protease production by shake flask culture (anyone).

2. Plasmid isolation and gel electrophoresis.

3. Bacterial transformation: Competent cell preparation, transformation, and screening of transformed isolates using blue-white screening.

4. Gene Expression analysis by IPTG induction under the Lac operon.

5. Bacteriophage titration, purification and quantification.

Suggested Readings

1. General Microbiology by R.Y. Stanier, JL Ingrahm, ML Wheelis and PR Painter.
2. Microbiology: Fundamentals and Applications by RM Atlas.
3. General Microbiology by HG Schlegel
4. Introduction to Modern Virology by NJ Dimmock, A J Easton and K N Leppard
5. Basic Virology by EK Wagner, MJ Hewlett, DC Bloom and D Camerini.
6. Microbiology by Prescott L, Harley J, Klein D.
7. Microbiology by Pelczar, Chan, and Krieg
8. Industrial Microbiology (2000) by AH Patel, Macmillan Publishers India
9. Industrial Microbiology by Prescott & Dunns, AVI Publishing Company Inc.

10. Industrial Microbiology by Casida LE, New age International (P) Ltd.
11. Adams & Moss, Food Microbiology, Published by Royal Society of Chemistry, Cambridge, U.K.
12. Industrial Microbiology, Author- G. Reed.
13. Industrial Microbiology, Author- Agarwal And Parihar.
14. Biology of Industrial Microorganisms. A.L. Demain.
15. Principles of Fermentation Technology, Authors- Standbary, Whitaker and Hall.

BOT 413
Mycota
Total marks 40; Credits 3; Class 45 hours

Course Outcomes (COs)

I. Understanding

- The physiological and biochemical processes of fungi such as nutrient sensing, signal transduction, metabolism, stress responses and secondary metabolite biosynthesis.
- The importance of fungal conservation and sustainable use in environmental management, food security, biotechnology and society.
- Genetic mechanisms controlling fungal reproduction, mating systems, inheritance, genomic variation, transposable elements and gene manipulation.

II. Memorizing

- Knowledge of the diversity, systematics, morphology, ecology, classification and DNA barcoding of fungi.
- Mycoses, mycotoxins, nutraceuticals, fermented foods and fungal bioproducts to assess the function of fungi in health and industry.

III. Applying

- Fungal applications in emerging technologies, such as fungal polysaccharides, bioactive metabolites, mycofumigation, and myconanotechnology.
- Participation in lifelong learning and professional development in the fields of mycology, biological sciences and biotechnology.

Program Outcomes (POs)

Upon successful completion of the course, students will be able to identify, classify, and interpret the evolution of fungi using fungal systematics, morphology, ecology, and DNA barcoding, and describe the cellular structure, physiology, metabolism, nutrient uptake, stress adaptation, and secondary metabolite synthesis of fungi. They can interpret genetic and molecular mechanisms of

growth, reproduction, inheritance, genomic variation and gene manipulation in fungi and assess the beneficial and harmful roles of fungi in medicine, food production, fermentation, nutraceuticals and biotechnology. They can evaluate fungal applications in mycofumigation, fungal polysaccharides, nanobiotechnology and sustainable bioprocesses.

Syllabus

Section-A

Fungal Systematics and Ecology: An overview of the Kingdom Mycota and its relation with allied kingdoms; Fungal cell structure; Structure and biology of fungal spores of different kinds; Classification of fungi; DNA Barcoding in fungal taxonomy; Linking functional diversity to taxonomic diversity; Fungi as mutualistic symbionts, Extremophilic fungi, Fungi as decomposers; Fungal conservation.

Section-B

Fungal Physiology and Biochemistry: Signal transduction pathways during hyphal morphogenesis and growth; Nutrient sensing (glucose and other nutrients) and uptake; Glycogen synthesis in fungi; Physiological significance of glycogen storage; Central metabolic pathway in yeast; Fungal secondary metabolites: Non-ribosomal peptides, Terpenes, Indole alkaloids, Polyketides; Heat shock protein in filamentous fungi.

Section-C

Fungal Cytology and Genetics: Genetics of asexual sporulation; Mating-Type switching in Yeasts; Mating pheromones in *Saccharomyces*; Non-sexual variations; Retroposons and retrotransposons in fungi; Extrachromosomal inheritance in fungi; Transformation and gene manipulation in filamentous fungi.

Section-D

Applied Mycology: Mycoses (Types, diagnosis and treatments); Mycotoxin; Functional food and dietary supplements from mushrooms; Fermented foods (Sake, Shochu, Vinegar and fermented soybean foods in East and Southeast Asia); Fungal polysaccharides in food processing; Mycofumigation; Myconanotechnology.

Practical

1. Introduction to basic mycological techniques and laboratory safety; Methods of sterilization, media preparation and culturing.

2. Morphological and reproductive structure of some macro- and micro-fungi.

3. Hyphal types from poroid fungi.

4. Identification of specimens from the field trip.

Suggested Readings

1. Cellular and Molecular Biology of Filamentous Fungi. Katherine A. Borkovich and Daniel J. Ebbole.
2. Modern Mycology. J. W. Deacon
3. Introduction to Fungi. John Webster and Roland W. S. Weber
4. Introduction to Mycology. C. J. Alexopoulos, C. W. Mims and M. Blackwell.
5. Fungi Nutrition & Physiology. Michael O. Garraway and Robert C. Evans.
6. Physiology of Fungi. Lilian E. Hawker
7. The Mycota; Vol: VII: Systematics and Evolution (Part A). K. Esser and P. A. Lemke.
8. The Mycota; Vol: III: Biochemistry and Molecular Biology. K. Esser and P. A. Lemke.
9. Gow NAR, Gadd GM. (1995) The growing fungus. Chapman & Hall.
10. Moore D, Manta MM, Evans SE, Rathore M. (2001) Fungal Conservation Issues and Solutions. Cambridge University Press.

BOT-414
Plant Disease Biology
Total Marks- 40; Credit-3; Class 45 hours

Course outcome (CO)

Understanding

- The biology, classification, symptomology, transmission, and host-pathogen interactions of major plant pathogens, including viruses, bacteria, fungi, and nematodes.
- The concepts of plant diseases and disorders differentiate between biotic and abiotic stresses, and analyze plant responses to environmental stress factors.

Memorizing

- Knowledge of plant pathology, disease biology, host-pathogen interactions, and crop protection strategies.
- The effects of salinity, drought, flooding, temperature extremes, nutrient deficiencies, pollutants, and light stress on plant growth and productivity.

Applying

- Interpret mechanisms of plant defense including structural, biochemical, localized, and systemic acquired resistance against biotic and abiotic stresses.
- Apply epidemiological principles to assess disease incidence, severity, disease progress, forecasting, and management of important endemic plant diseases.

Programme Outcomes (PO)

Upon completion of the syllabus, the students will be able to demonstrate comprehensive knowledge of plant pathology, disease biology, host-pathogen interactions, and crop protection strategies and identify plant health problems, analyze causal factors, and formulate evidence-based disease management solutions.

Syllabus

Section-A

Biology of Plant Diseases Related to Abiotic Factors

Plant-abiotic factor interaction and disorders of plants: A brief concept of diseases and disorders of plants;, abiotic factors leading to disorders: salinity, drought, water-logging, temperature extremes, micronutrient deficiency, pollutants (including toxic gases, heavy metals, particulate matters, chemical pesticides, herbicides), light extremes, UV damage, symptoms of disorders associated with abiotic factors, host factors associated with environmental susceptibility. Concept of genetically modified abiotic stress tolerant crop lines. Concept on structural and biochemical adaptations against abiotic stresses.

Section-B

Biology of Plant Diseases Caused by Biotic Stresses

Biology of plant diseases: Classification of plant diseases. Diseases caused by biotrophic, necrotrophic and hemibiotrophic pathogens, localized and systemic acquired resistance. Symptomology of important plant viral diseases, transmission, virus vector relationship, replication and movement of plant viruses. Plant pathogenic bacteria, symptomology of plant bacterial diseases, crown gall disease, bacterial blights. Diseases caused by nematodes, symptoms, interaction of nematodes with trap fungi as biocontrol agents. Diseases caused by phytopathogenic fungi. Insect herbivory, major groups of crop insects, mining, boring and sucking insects. Concept on structural and biochemical adaptations against biotic stresses.

Section-C

Plant Disease Epidemiology and Advanced Diagnostics

Epidemiology of plant diseases, endemic diseases and forecasting and detection of diseases: General information, terms and definitions in diseases epidemiology, history of plant epidemics. Elements of epidemics, disease triangle, disease tetrahedron, Factors affecting the elements of epidemic. Measurement of plant disease in field: disease severity, disease incidence, disease index, types and patterns of epidemics, disease progress curves, disease gradient curves. Disease forecasting, computer simulation. Epidemiology of selected endemic diseases of India with reference to local conditions: *Ralstonia* wilt disease of Tomato, fungal blight of rice (*Rhizoctonia solani*), Wheat blast (*Magnaporthe oryzae Triticum*), Mungbean yellow mosaic disease, *Alternaria* blight of mustard, Anthracnose of chilli (*Colletotrichum sp*), Black mould of onion (*Aspergillus niger*), Root knot of brinjal by nematodes (*Meloidogyne spp*), Red rust of tea (*Cephaleuros virescens*). Diagnosis of plant diseases; from field diagnosis to molecular diagnosis, Detection of latent diseases, PCR based molecular finger printing of pathogen populations and immuno-detection of plant diseases.

Section-D

Prevention and Molecular Control of Plant Diseases: Agricultural practices and remedial measures for prevention of disease, plant quarantine, crop rotation, mixed cultivation, use of barrier plantation. Integrated disease management: basic principles and importance. Methods of generating disease resistance crop lines: Conventional methods of generating disease tolerant plants though plant breeding and its limitations. Control of plant diseases through transgenic approaches. Isolation and molecular cloning of disease resistance genes, promoters and reporters

used for improved tolerance, assay of disease tolerant crop lines. Use of enzyme inhibitor genes for insect resistance; Advantages and disadvantages.

Practical

1. Isolation of pathogens from diseased plant samples
2. Study of symptoms of selected diseases of dicots and monocots.
3. Histopathology of diseased plants
4. Study of trichomes
5. Identification of common fungal phytopathogens
6. Detection of latent viral infection in plants
7. Study of selected insects important for plant herbivory
8. Estimation of super-oxide dismutase
9. Localization of ROS due to abiotic stresses
10. Detection of cell necrosis

Suggested Readings

1. Plant Pathology – Agrios
2. Plant Pathology – Mehrotra & Aggarwal
3. Plant Virology – Roger Hull
4. The Study of Plant Disease Epidemics – Madden et al.
5. Plant Biotechnology and Genetics – C. Neal Stewart Jr.

BOT 415

Indian Knowledge System in Plant Science

Total Marks- 20; Credit-2; Class 30 hours

Course Outcomes (COs)

Understanding

- The role of traditional ecological knowledge in biodiversity conservation.
- Ayurvedic concepts explained and correlated with medicinal botany and health care.
- Traditional fermentation principles, classification, and processes
- Fermented foods and beverages are important in the areas of nutrition, therapy and society-culture.

Memorizing

- Significance of medicinal plants, Ayurveda, Yoga and aromatherapy in health promotion and biodiversity conservation.
- The concepts, characteristics and importance of IKS in plant resource utilization and livelihoods.

- Ayurvedic principles, diagnostics, and therapeutic practices

Applying

- Traditional knowledge with scientific approaches for sustainable development.
- Ayurvedic concepts explained and correlated with medicinal botany and health care.
- Evaluate Indigenous agricultural practices for sustainable resource management.

Program Outcomes (POs)

Students will be able to correlate the knowledge of IKS and its application to plant science, health, agriculture, and food systems and evaluate the ethnobotanical resources used by the indigenous peoples. They can combine the role of traditional ecological knowledge in biodiversity conservation and investigate traditional fermentation technologies and their importance for nutrition and culture.

Syllabus

Section-A

Introduction to Indian Knowledge Systems: Definition and characteristics; The relevance of Traditional knowledge and practices with suitable examples; Plants used by the indigenous societies: a) Food plants, b) Medicinal plants, c) intoxicants and beverages, d) Resins and oils and miscellaneous uses.

Section-B

Indian Health Sciences: Vedic foundations of Ayurveda. Basic concepts of Ayurveda, importance of agni, doshas, and rasas. The diagnostic methods and therapeutic practices of Ayurveda. Understanding the holistic approach to health encompassing physical, mental, and spiritual well-being. Application of Ayurvedic principles in contemporary healthcare systems. Ayurvedic perspectives on health, including dietary regimes, disease management, elements of wellness—and their intersections with botany and medical science, Medicinal Botany in IKS, Modern relevance of IKS in Medicinal Botany and Biodiversity Conservation, Current revival of Ayurveda, Yoga and aroma therapy.

Section-C

Indian knowledge system in sustainable agriculture: Principles of Indian knowledge system in agriculture; Importance of traditional varieties; seed conservation; Criteria for crop selection; Nutrient management; Water management; Pest and weed management; Contribution of IKS to sustainable agriculture.

Section-D

Indian knowledge system in fermented products: Definition of Fermentation; Traditional Indian Fermented products, types of fermented products and their classification. Fermentation of vegetables, cereals and milk; Nutritional and health benefits of fermented products.

Suggested Readings

1. Mahadevan et al. – Introduction to Indian Knowledge System
2. Sharma, P.V. – Introduction to Dravyaguna Vijnana
3. Kirtikar & Basu – Indian Medicinal Plants
4. Jain, S.K. – A Manual of Ethnobotany
5. Primack – Essentials of Conservation Biology
6. Lad, V. – Textbook of Ayurveda

BOT 416

Combined Practical Paper-I

Total Marks- 70; Credit-6; Class 90 hours

Syllabus: Prescribed Practical as mentioned in Paper BOT 411, 412, 413 and 414**.**

2nd Semester

BOT 421

Plant Systematics and Biodiversity

Total Marks- 40; Credit-3; Class 45 hours

Course Outcomes (CO):

III. Understanding

- Comprehensive understanding of plant diversity, nomenclature and classification, evolution, ecology, and conservation.
- Commitment to biodiversity conservation, sustainable development, and ethical scientific practices.

II. Memorizing

- The principles and evolutionary basis of major angiosperm classification systems including Cronquist, Takhtajan, Thorne, and APG IV, and evaluate their phylogenetic significance.
- The diversity, characteristics, phylogeny, and evolutionary trends of major angiosperm groups such as Magnoliidae, Asteridae, Alismatidae, and Liliidae.

III. Applying

- Principles of plant taxonomy, nomenclature, and biosystematics for identification and classification of plants.
- Evaluate conservation priorities using IUCN criteria, Red Data Books, CITES, and other biodiversity assessment frameworks.
- Molecular markers, DNA barcoding, GIS, remote sensing, and bioinformatics tools in biodiversity studies.

Programme Outcomes (POs)

Upon completion of this course, students will be able to understand major classification and nomenclature, cladistic methodology and interpret phylogenetic relationships among major angiosperm clades, including palaeoherbs, monocots, and eudicots and utilize classical and modern taxonomic data sources including anatomy, embryology, ultrastructure, molecular markers, and DNA barcoding for plant identification and classification.

Section-A

Classification, cladistics and angiosperm diversity: Components of major systems of classification: Cronquist (1981), Takhtajan's System (2009), Thorne (2007); APG Classification, APG IV (2016), emphasis on major clades; Concepts of palaeo herbs and eu-dicots (tricolpates). Cladistics: Components, methodology and implications; Angiosperm diversity: General characteristics, phylogeny and evolutionary trends in Magnollidae, Asteridae, Alismatidae, and Liliidae (sensu Cronquist, 1981).

Section-B

International Code of (Botanical) Nomenclature (ICN): Principles, latest changes, typification: methods with emphasis on lectotypification, neotypification and epitypification; priority of names; effective and valid publications: new provisions; Names of new taxa (species); new combinations; names at new rank; replacement of names, rejection of names; Proposed BioCode and PhyloCode.

Section-C

Tools of Taxonomy, Species and Biosystematics: Data sources in Taxonomy: Embryology, Anatomy and ultrastructure; Molecular taxonomy–DNA barcoding; Tools of Taxonomy: Application of GIS and GNSS (Remote Sensing) in Taxonomy and Biodiversity. Species concept; Biosystematics: Objectives, steps, categories, relevance with classical taxonomy; Numerical Taxonomy: Principles and applications.

Section-D

Biodiversity, Conservation and IUCN: Concept, levels, components, of biodiversity, hotspots and hottest hotspots, mega diversity centers of world, loss of biodiversity. Role of Taxonomy in Biodiversity Conservation. IUCN threat categories: methods of assessment; strategies for in situ and ex situ conservation; CITES and TRAFFIC; Red Data Book.

Practical

1. Work out of plant specimens and description of vegetative and reproductive characters from representative families.
2. Training in identification of specimens described in classes using relevant literature and herbaria.
3. Study of various taxa of a genus, determining key characters and preparation of keys at species and genus level.
4. Basic techniques of molecular systematics, including DNA extraction, amplification, gel electrophoresis. Exercise on analyzing molecular sequence data using various computer software.
5. Field excursion for familiarization with and study of vegetation type(s) and flora(s) of areas outside the state/different ecological zone, and in the local areas, and training in collection and preservation methodologies. Submission of at least 20 herbarium specimens of common plants.

Suggested Readings

1. Datta, S. C. 1988. Systematic Botany.Wiley Eastern Limited, New Delhi.
2. Davis, P. H. and Heywood, V. H. 1963. Principles of Angiosperm Taxonomy. Princeton, NJ: Van Nostrand.
3. Johnes, S. B. and Luchsinger, A. E. 1987. Plant Systematics.McGraw-Hill. London.
4. Judd, W. S., Campbell, C. S., Kellogg, E. A., Stevens, P. F., Donoghue, M. J. 2008. Plant Systematics – A Phylogenetic Approach.SinauerAssoociates, Inc., Sunderland, Massachusetts USA.
5. Lawrence, G. H. M. 1964. Taxonomy of Vascular Plants.Oxford & IBH Publishers, Calcutta.
6. Naik, V. N. 1984. Taxonomy of Angiosperms. Tata McGraw-Hill Publishing Company Limited, New Delhi.
7. Radford, A. E. 1986. Fundamentals of Plant Systematics.Harper & Row, London.
8. Simpson, M. G. 2010. Plant Systematics. Elsevier Academic Press, Amsterdam.
9. Singh, G. 2012. Plant Systematics – Theory and Practice. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi.
10. Sivarajan, V. V. 1991. Introduction to the Principles of Plant Taxonomy. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi.
11. Stace, C. A. 1989. Plant Taxonomy and Biosystematics.Arnold Publishers, United Kingdom.
12. Stuessy, T. F. 2008. Plant Taxonomy – The Systematic Evaluation of Comparative Data.Columbia University press, New York.

BOT 422

Cell Biology

Total Marks- 40; Credit-3; Class 45 hours

Course Outcomes (CO):

Understanding

- Learn, understand, and develop skills through hands-on training in the basics of cell biology.
- Develop technical expertise in advanced cell biology techniques, including fluorescence microscopy, cell fractionation, and organelle characterization.

Memorizing

- The structural and functional aspects of cellular organelles.
- The molecular mechanisms governing DNA replication, genome stability, and gene expression.
- The molecular mechanisms governing protein folding, modification, sorting, and intracellular transport.

Applying

- Building research competency through experimental design, data analysis, interpretation, and scientific communication in cell and molecular biology.
- Apply knowledge of modern molecular biology tools and RNA-based technologies in plant research, biotechnology, and genomics.
- Training the students to be economically independent by learning viable molecular biology techniques.

Programme Outcomes (POs)

Upon completion of this course, students will be able to critically analyze cellular structures and processes using modern cell biology techniques and apply this knowledge to address research questions in life sciences and make themselves capable of applying these techniques in biotechnology and medicine-based fields.

Syllabus

Section-A

Modern Tools and Techniques in Cell Biology: I. Principles and applications of modern light microscopy, fluorescence microscopy, and electron microscopy (SEM and TEM), Scanning Transmission Electron Microscopy (STEM); Super resolution microscopy, Total internal reflection fluorescence microscopy (TIRF), FRET microscopy. Different fixation and staining

techniques for EM, image processing. II. Different processes of subcellular fractionation and visualization. Differential and density gradient centrifugation, Magnetic separation. III. Digital imaging, live-cell imaging, image analysis, and applications in cell biology research.

Section-B

Cell and cell organelles: I. Cell wall- building blocks, architecture, macromolecules involved, Plasma membrane-structure (physical structure of the bilayer, components) and function, pumps, channels and transporters. Chloroplasts, mitochondria, and Golgi bodies (structures only). II. Cytoskeleton- different types (actin, intermediate filaments, microtubules), structures, components and assembly, associated proteins, motors- structures and function.

Section-C

Nucleus: Chromosome territories, topological associated domains, lamina-associated domains, structural and functional organization of chromatin, histone modification, euchromatin and hetero chromatin, X chromosome inactivation, Role of chromatin in gene expression and gene silencing. Centromere and telomere structure, nucleolus, Nuclear transport.

Section-D

Molecular Basis of Gene Expression and Regulation: I. Molecular Mechanism of Replication, Transcription and Translation. Control of gene expression at transcription and translation levels. II. Role of chromatin in gene expression and gene silencing. Post-translational modification, III. Transcriptomics: Definition, Types, Techniques, Applications.

Protein Sorting, Vesicular Transport, and Endomembrane Dynamics: I. Protein Folding, Processing, and Targeting, II. Endomembrane System and Intracellular Trafficking, III. Vesicular Transport Mechanisms: COPI-, COPII-, and clathrin-mediated vesicular trafficking, IV. Endocytosis and Cellular Uptake Processes: Endocytosis, receptor-mediated endocytosis, phagocytosis, and intracellular trafficking pathways, V. Organelle-Specific Protein Targeting: Mechanisms of protein import and post-translational uptake into peroxisomes, mitochondria, and chloroplasts.

Practical

1. Isolation of plant genomic DNA, purity estimation by UV spectroscopy, and visualization by agarose gel electrophoresis.

2. Determination of antigen concentration by the sandwich ELISA method.

3. Cell Cycle analysis by FACS (Demonstration)

4. Staining of mitochondria by Janus Green B

5. Estimation of lipid peroxidation

6. Estimation of protein by the Lowry method and standard curve preparation.

7. Isolation of protein from plant samples and electrophoresis by SDS-PAGE.

Suggested Readings

1. The World of the Cell- Becker WM et al,- Benjamin Cummings
2. Cells- Benjamin Lewin, Lynne Cassimeris, Vishwanath R. Lingappa, George Piopper Jones and Bartlett Publishers, 3rd edition.
3. Molecular Cell Biology-Lodish Hetal., - Freeman
4. Essential Cell Biology, Alberts Betal.,- Garland
5. Molecular Biology of the Cell, Alberts Bet al., -Garland
6. Cell and Molecular Biology: Concepts and Experiments. By Gerald Karp, Wiley, 7th edition
7. Cell and Molecular Biology, De Robertis and De Robertis–Lippincott and Wilkins.
8. Cell and Molecular Biology-Phillip Sheeler; Donald E. Bianchi. Published by John Wiley& Sons, 3rd edition.
9. GenesIX-Lewin B– Pearson.
10. Genomes-Brown TA-Garland
11. Molecular Biology of the Gene-Watson et al. Pearson 7th edition.
12. Fundamental Molecular Biology-By Lizabeth A. Allison. Wiley-Blackwell2ndedition

BOT 423

Phytochemistry

Total Marks- 40; Credit-3; Class 45 hours

Course Outcomes (CO):

I. Understanding

- Advanced knowledge of plant sciences, phytochemistry, pharmacognosy, biotechnology, and medicinal plant research.
- Patents, copyrights, geographical indications, biodiversity laws, and intellectual property rights related to plant resources.
- Sustainable utilization, conservation, and management of medicinal plant resources and biodiversity.

II. Memorizing

- Analytical, spectroscopic tools for scientific investigations.
- Scientific principles and modern analytical techniques for the isolation, characterization, evaluation, and development of bioactive compounds from natural resources
- Ethical practices, biosafety guidelines, pharmacovigilance standards, and regulatory frameworks governing natural products.

- Continuous learning of emerging developments in plant sciences, biotechnology, and healthcare sectors.

III. Applying

- Designing, conducting, interpreting, and communicating research in plant sciences, natural product chemistry, and drug discovery.
- Apply knowledge for developing herbal products, phytopharmaceuticals, nutraceuticals, and plant-based technologies.
- Analyzing and solving complex biological and biomedical problems using scientific reasoning and evidence-based approaches.

Programme Outcomes (POs)

Upon successful completion of this course, students will be able to explain fundamental concepts of phytochemistry, pharmacognosy, biomedicine, and the physicochemical properties influencing drug behaviour and drug-likeness. They will learn about medicinal plants and phytochemicals as potential therapeutic agents, with special reference to anticancer and antidiabetic drug discovery. They can integrate phytochemical, pharmacological, regulatory, and ethnobotanical knowledge for research, innovation, and sustainable development of plant-derived therapeutics.

Syllabus

Section-A

Introduction to Phytochemistry, Pharmacognosy and Plant-Based Drug Discovery: Fundamentals of Phytochemistry and Pharmacognosy: Phytochemistry, Pharmacognosy and Biomedical Applications, Medicinal plants and their role in healthcare, biomedicine, nutraceuticals, and phytopharmaceuticals. Drug: Definition and classification of drugs, Physicochemical properties influencing drug action- solubility, lipophilicity, hydrogen bonding, surface binding, and polar surface area, Drug-likeness concepts-Lipinski's Rule of Five, Pfizer's 3/75 Rule, and related predictive models, Introduction to ADMET and pharmacokinetic principles. Drug Discovery Cycle: Basics of drug discovery phase and drug development phase. Natural Product-Based Drug Discovery: Drug discovery pipeline, target identification, lead discovery, lead optimization, and candidate selection, advantages and disadvantages. Plant-Derived Therapeutics: Case studies of important plant-derived drugs: Vincristine and Vinblastine, Taxol, Camptothecin, Podophyllotoxin, Artemisinin. Toxicology and Regulatory Frameworks: Principles of toxicity evaluation and safety assessment, OECD guidelines for toxicity studies, Regulatory requirements for herbal medicines, phytopharmaceuticals, and botanical drugs.

Section-B

Biosynthetic Pathways and Phytochemical Analyses: Biosynthetic pathways for the synthesis of secondary metabolites: saturated and unsaturated fatty acids, polyketides, terpenoids, steroids, alkaloids, phenols, aromatic amino acids, lignins, lignans, glycosides, carotenoids, apocarotenoids.

Extraction, separation, isolation, purification and characterization of bioactive compounds from plant extracts using different chromatographic and spectroscopic techniques. Classical and modern approaches for quality control of plant drugs, chemical races, phytochemicals as anti-nutrients.

Section-C

Phytochemicals and Plant Metabolomics: Concept of nutraceuticals and functional food, classification. Chemical nature, classification, types and biological activities of the following: Carbohydrates, cellulose derivatives and sugar alcohols, Glycosides, Alkaloids, Phenolic compounds, steroids and sterols, carotenoids, EFAs and non-EFAs, Saturated, unsaturated and trans-fats, fixed oils, waxes, Essential oils (aromatherapy), resinous compounds, vitamins. Plant Metabolomics: terms and definition, different metabolomics technologies, merits and demerits, data acquisition and applications. Role of compartmentation in plant secondary metabolism, metabolite trafficking

Section-D

Bioprospecting, Natural Product Research, Intellectual Property Rights and Pharmacovigilance: Bioprospecting and Ethnobotanical Approaches: Concept, scope, and significance of bioprospecting in natural product research and drug discovery, Biopiracy and conservation of indigenous knowledge. Bioactivity-Guided Natural Product Discovery: Principles and strategies of bioactivity-guided fractionation with special emphasis on Cancer and Diabetes. Spectroscopic and Analytical Techniques for Compound Characterization: Brief idea about compound identification through spectroscopic techniques (UV, IR, MS, ESIMS, 1H NMR and 13C NMR). Intellectual Property Rights and Regulatory Frameworks: Introduction to Intellectual Property Rights (IPR) in biological sciences; Indian and international patent laws, proposed amendments as applicable to herbal/natural products and process; Copyright, Patentable subject matters, Traditional Knowledge, and Biodiversity-related IPR issues, Legal and ethical aspects of commercialization of plant-based products. Pharmacovigilance and Safety Monitoring of Natural Products: Concepts and importance of pharmacovigilance for herbal medicines and natural products, WHO and AYUSH guidelines for safety assessment and monitoring of herbal drugs.

Practical

1. Preparation of plant extracts using different solvents and their TLC profiling.

2. Preliminary phytochemical screening, qualitative chemical examination, choice of solvents for the extraction of important metabolites

2. Detection of phytochemicals: alkaloids, hydrolysable and condensed tannins, phenols, flavonoids, pigments, steroids, cardiac glycosides, anthraquinones

3. Chemicals tests for acellular crude drugs: aloes, agar, pectin, acacia, tragacanth, asafoetida

4. Microscopic study of starch grains from different plant sources

5. Detection of caffeine and theobromine in coffee; strychnine and brucine in *Stychnos nux- vomica* mother tincture, reserpine in *Rauvolfia* root powder, gallic acid in Myrobolans, standard beta sitosterol and diosgenin using the thin layer chromatographic technique

6. Isolation of Caffeine from tea leaves. Confirmatory test for Caffeine.

Suggested Readings

1. Paul M. Dewick, 2009. 3rd Edition, Medicinal Natural Products: A biosynthetic Approach, John Wiley & Sons Ltd.
2. Bruneton J., 1999. Pharmacognosy, Phytochemistry, Medicinal Plants, Intercept Ltd., Paris 3. Evans W.C., 2009, 16th Edition, Trease and Evans. Pharmacognosy, W.B. Saunders
4. Textbook of Pharmacognosy and Phytochemistry. Biren Shah & A.K. Seth.ELSEVIER, 2010
5. Cereal Grain-based Functional Foods Carbohydrate and Phytochemical Components. Edited by Trust Betaand Mary Ellen Camire. Royal Society of Chemistry, 2018.
6. Textbook of Pharmacognosy. Dr. Mohammed Ali. CBS PUBLISHERS & DISTRIBUTORS. Reprint 2005.
7. Phenolic compound Biochemistry. Wilfred Vermerris& Ralph Nicholson. 2006. Springer.
8. Harbourne, J.B., 1998. Phytochemical Methods, Chapman and Hall.
9. Kolkate C.K., 1991. Practical Pharmacognosy, Vallabh Prakashan, Delhi
10. Samuelsson G., 1999. Drugs of natural origin: A textbook of Pharmacognosy, Apotekarsocieteten, Swedish Pharmaceutical Society, Swedish Pharmaceutical Press, Stockholm, Sweden.
11. Tyler V. E., L. R. Brady and J. E. Robbers, 1988. Pharmacognosy, Indian Edition, K.M Varghese
12. Vickery M.L. and B. Vickery, 1981. Secondary Plant Metabolism, The MacMillan Press Ltd.
13. Wallis T. 1967. Textbook of Pharmacognosy, J & A Churchill, London.
14. Wagner H., S. Bladt and E.M. Zgainiski (Translated by A. Scott) 1984, Plant Drug Analysis. Springer-Verlag
15. Molecular Biology and Biotechnology: A Comprehensive Desk Reference Ed. Robert A. Meyers. 1995
16. Chromatography And Its Applications. Edited by Sasikumar Dhanarasu. Published by In Tech, 2012
17. Principles and Practice of Chromatography. Chrom-Ed Book Series. Raymond P. W. Scott 18. Phytochemistry- Pharmacognosy, Nanomedicine and Contemporary issues. Edited by Chukwuebuka Egbuna, Shashank Kumar, Jonathan ChinenyeIfemeje, JayaVikasKurhekar. Apple Academic Press.

BOT 424

Genetics and Genomics

Total Marks- 40; Credit-3; Class 45 hours

Course Outcomes (CO):

I. Understanding

- Genome organization, genome mapping, sequencing technologies, comparative genomics, transposable elements, and genome evolution.
- Proteomics principles, protein purification, protein identification, protein-protein interactions, and mass spectrometry-based analyses.
- Mechanisms of DNA mutation, repair pathways, homologous recombination, and genome maintenance processes

II. Memorizing

- Sex-linked inheritance, extra-chromosomal inheritance, and inheritance of complex traits relevant to plant breeding and human diseases.
- Chromosomal basis of inheritance, Mendelian and non-Mendelian inheritance patterns, gene concepts, and epigenetic mechanisms.

III. Applying

- Gene function using forward and reverse genetics, gene tagging, knock-out/knock-down strategies, and mutagenesis techniques.
- Molecular phylogenetic relationships using genetic diversity, molecular clock, and DNA sequence data.
- Regulation of gene expression, genome-wide association studies (GWAS), differential gene expression analysis, and functional genomics approaches.

Programme Outcomes (POs)

Upon completion of this course, students will be able to critically demonstrate comprehensive knowledge of genetics, genomics, molecular biology, evolution, and plant sciences. They can interpret genetic and genomic data to formulate scientific explanations and hypotheses. They will be able to apply genetic and genomic principles in plant breeding, biodiversity conservation, disease management, and biotechnology.

Syllabus

Section-A

Understanding patterns of inheritance and Principles of Genetics: I. Chromosomal basis of inheritance: Morgan's experiments, Cell division dynamics. II. Traditional and modern concepts of gene: From Mendel's factor to the one-gene-one-enzyme hypothesis, Modern concept of gene. III. Mendelian genetics and extensions of Mendelism. IV. Extra-chromosomal inheritance and importance in plant improvement. V. Inheritance of complex traits and problems in plant breeding. V. Sex-linked inheritance: Pedigree analysis for assessing disease inheritance. VI. Epigenetic inheritance, Genome imprinting

Section-B

Population Genetics, Quantitative Genetics and Molecular Evolution: I. Population structure: Allele and genotype frequencies, Effective population size. II. Hardy-Weinberg equilibrium: H-W hypothesis, Sex linked loci and HW equilibrium, Linkage and linkage disequilibrium. III. Factors affecting allele frequencies: Natural and artificial selection, Mutation, Migration, Genetic drift, non-random mating and inbreeding. IV. Quantitative traits: Calculating genetic and environmental components of variation, Application in plant breeding. V. Molecular phylogenetics: Using DNA sequences for phylogenetic analysis; Genetic diversity, Genetic distance, Measures of relatedness. VI. Molecular Clock, Concept and Hypothesis.

Section-C

Genome organization and analysis: I. Physical and genetic features of eukaryotic genomes: Chloroplast genome, Mitochondrial genome, Nuclear genome, Genome size and complexity: C-value paradox. II. Mapping Genomes: Genetic Mapping: RFLP, RAPD, and AFLP; Physical Mapping: Restriction maps. III. Sequencing of Genomes: Chain termination DNA sequencing, Next generation sequencing, Sequence assembly (shotgun, clone contig method). IV. Locating genes in a genome sequence: Positional cloning and comparative genomics. V. Genome evolution: Structure and function of transposable elements (Ac/Ds), Molecular features of Ac/Ds transposable elements. VI. Mutation and DNA repair pathways: Proof-reading and mismatch repair, Direct repair mechanisms, Excision repair, Error-prone repair mechanisms. Double-strand break repair: Homologous recombination (HR), Non-homologous end joining (NHEJ), Recombination repair and its role in maintaining genome integrity.

Section-D

Functional Genomics: I. Regulation of gene expression: Spatial and temporal regulation of gene expression, RNA polymerases and general transcription machinery, Cis-regulatory elements and transcription factors, Enhancers, silencers, and promoter architecture. II. *In situ* hybridization: FISH and GISH, Chromosome painting, Comparative genomic hybridization (CGH). III. Approaches to analyze differential gene expression: Microarray, ESTs. IV. Determining the function of individual genes (Forward and Reverse genetics approach): Gene tagging, Gene

trapping, Knock out and Knock down, *In vitro* mutagenesis and deletions. V. Concept of the proteome and its dynamic nature, Post-translational modifications (PTMs). VI. Proteomics in biology: Understanding cellular function, Role of proteomics in functional validation of genes. Differential gel electrophoresis (DIGE). Protein identification: Peptide mass fingerprinting, Microsequencing approaches. VII. Protein–protein interactions: Yeast two-hybrid system, BiFC. VIII. Mass Spectrometry in Proteomics: Principles of mass spectrometry, Ionization techniques: MALDI-TOF, Electrospray ionization (ESI).

Practical

1. Techniques of chromosome analysis: Study of normal and deviant meiosis and mitosis in selected plants

2. Analysis of molecular variation using markers: similarity analysis and molecular phylogeny reconstruction

3. Restriction Mapping of a DNA fragment

4. Differential expression of a gene by semiquantitative RT PCR

Suggested Readings

1. Genetics: A Conceptual Approach: Pierce, B. A. — W. H. Freeman
2. Principles of Genetics: Snustad, D. P., & Simmons, M. J. — John Wiley & Sons
3. Genetics: Analysis of Genes and Genomes: Hartl, D. L., & Jones, E. W. — Jones & Bartlett
4. Molecular Biology of the Cell: Alberts, B. et al. — Garland Science
5. Molecular Cell Biology: Lodish, H. et al. — W. H. Freeman
6. Cell and Molecular Biology: De Robertis, E. D. P., & De Robertis, E. M. F. — Lippincott Williams & Wilkins
7. Genomes: Brown, T. A. — Garland Science
8. Advanced Molecular Biology: Twyman, R. M. — Garland Science
9. Recombinant DNA: Genes and Genomes—A Short Course: Watson, J. D. et al. — Macmillan
10. Principles of Population Genetics: Hartl, D. L., & Clark, A. G. — Sinauer Associates
11. Introduction to Quantitative Genetics: Falconer, D. S., & Mackay, T. F. C. — Pearson

BOT 425

Research Methodology

Total Marks- 20; Credit-2; Class 30 hours

Course Outcomes (COs)

Understanding

- Biological research problems, develop research questions, hypotheses, and conceptual frameworks based on scientific evidence
- Intellectual property rights, biosafety, bioethics, research ethics, data management, and reproducibility in biological research.

Memorizing

- Fundamental and advanced concepts of biological sciences to understand living systems and solve scientific problems.
- Bioinformatics resources, scientific databases, digital tools, and information technologies for research and lifelong learning.

Applying

- Integrity in research by adhering to ethical guidelines, biosafety regulations, intellectual property rights, and publication ethics.
- Appropriate scientific writing practices, referencing tools, publication standards, and plagiarism prevention techniques for effective research communication.

Programme Outcomes (POs)

Upon completion of the programme, students will be able to apply fundamental and advanced concepts of biological sciences to understand living systems and solve scientific problems analyze biological data, evaluate evidence, formulate hypotheses, and develop scientifically sound solutions. They can design, conduct, interpret, and communicate research using appropriate methodologies, statistical tools, and scientific literature.

Syllabus

Section-A

Research problem and literature review: I. Identification and formulation of research, II. Research questions and hypothesis, III. Sources of scientific literature, IV. Literature searching using: PubMed, Scopus, Web of Science, Google Scholar, V. Critical review of literature, VI. Gap analysis and conceptual framework. Measurable research index: Journal impact factor, SJR, SNIP, h-index, i10-index, g-index, etc.

Section-B

Research design and experimental planning: I. Principles of experimental design, Variables and controls, Randomization, replication; II. Experimental and observational studies, III. Sampling methods and sample size determination, IV. Pilot studies.

Section-C

Scientific writing: I. Writing scientific papers, II. Referencing tools used in scientific writing, III. Plagiarism and plagiarism detection, IV. Peer review process, V. Publication ethics and predatory journals

Section-D

Intellectual property rights and research ethics: I. IPR, Patents, copyrights and trademarks, II. Biosafety and bioethics, III. Ethical guidelines for biological research, IV. Data management and reproducibility

Suggested Readings

1. Research Methodology: Methods and Techniques – Kothari & Garg.
2. Research Design – Creswell & Creswell.
3. Design and Analysis of Experiments – Montgomery.
4. How to Write and Publish a Scientific Paper – Day & Gastel.
5. Bioethics and Biosafety – M.K. Sateesh.

BOT 426

Combined Practical Paper-II

Total Marks- 70; Credit-6; Class 90 hours

Syllabus: Prescribed Practical as mentioned in Paper BOT 421, 422, 423 and 424

3rd Semester

BOT 511

MOOCS & SWAYAM

Total Marks- 50; Credit-4; Class 60 hours

Online course from SWAYAM Portal

BOT 512

Biostatistics, Bioinformatics and Artificial Intelligence in Plant Sciences

Total Marks- 40; Credit-3; Class 45 hours

Course Outcomes (CO):

I. Understanding

- Modern software, databases, and programming resources for biological investigations
- Computational and statistical methods to analyse biological data and solve research problems.
- Evaluation of scientific literature, datasets, and computational predictions.
- Sequence alignment, similarity searches, and phylogenetic analyses using standard bioinformatics tools.
- Application of Artificial Intelligence in different aspects of Plant Sciences.

II. Memorizing

- Concepts, scope, and applications of bioinformatics and computational biology in modern life sciences
- Computational approaches, including virtual screening, molecular docking, QSAR, and ADMET prediction in drug discovery research.
- Molecular dynamics simulations and interpret biomolecular interactions using modern computational methods.
- Protein structures, visualize macromolecules, and construct homology models using computational platforms.

III. Applying

- Perform sequence alignment, similarity searches, and phylogenetic analyses using standard bioinformatics tools.
- Retrieve, manage, and analyse biological information from major nucleotide, protein, genome, and structural databases.
- ADMET prediction, Molecular docking, and molecular dynamics simulation for computational drug discovery.

Programme Outcomes (POs)

Upon successful completion of this course, students will be able to apply advanced knowledge of bioinformatics and computational biology in drug discovery sectors and biological and computational knowledge for sustainable development, biodiversity conservation, and societal well-being. It can also develop entrepreneurial and innovation skills for careers in biotechnology and AI-assisted drug discovery industries.

Syllabus

Section-A

Statistical Methods in Biology: Frequency distribution, Measures of central tendency and dispersion, Probability distributions: Binomial, Poisson, Normal (Gaussian), Sampling distributions and standard error, Parametric and non-parametric statistics, Hypothesis testing: Null and alternative hypotheses, Levels of significance and p-values, Type I and Type II errors, Confidence intervals, Statistical tests: t-test, Chi-square (χ^2) test, Fisher's exact test, Analysis of variance (ANOVA), Correlation and regression, Introduction to multivariate statistics; Computational Tools and Data Analysis: Use of public domain software/tools for: Chi-square (χ^2) test, Fisher's exact test, t-test, Multiple testing corrections, Interpretation of statistical outputs in biological research.

Section-B

Introduction to Bioinformatics: Role of bioinformatics in modern biological research; Overview and applications of biological databases, Major databases: Nucleotide databases: GenBank, EMBL, Protein databases, Structural databases: Protein Data Bank (PDB), Data storage formats: Flat files and relational databases, Sequence alignment: Local and global alignment, Pairwise and multiple sequence alignment, Scoring systems and substitution matrices (PAM, BLOSUM), Sequence similarity: Homology and analogy, Database search tools (BLAST); Structural Bioinformatics: Properties of amino acids and peptide bonds; Protein stability and folding (Ramachandran plot); Protein Structure Database (Protein Data Bank); Protein Structural Visualization (RasMol, PyMOL, DSV); Homology modelling (SwissMODEL).

Section-C

Computational drug discovery and designing: Bioinformatics in drug discovery and development (*In silico* drug designing); High Throughput Screening; Virtual screening; Quantitative Structure-Activity Relationship; Principles of drug development; ADME properties; Improving on the lead compound; Drug target identification and validation; Active sites; Grid boxes; Molecular docking; Tools and molecular docking programs (AutoDock, Patchdock); Molecular dynamics- setting and running a molecular dynamics; Molecular dynamics using simple models; Trajectory analysis, CHARMM, Monte Carlo simulation.

Section-D

AI in Plant Science: History and Concept of AI: Machine learning vs Deep learning, Task classification of AI, Decision tree induction, Artificial Neural Networks, Hidden Markov Models, Evaluation of prediction methods: Parametric and Non-parametric tests, Clustering (Hierarchical and K-means), Principal Component Analysis. AI for microscopy and imaging (automatic cell segmentation, cell counting, cell tracking), RNA-sequencing analysis, Protein structure prediction(alphafold-3)- confidence score, possible interaction between two proteins, AI for drug discovery- toxicity prediction, drug target site prediction. Application of AI in plant identification and precision farming.

Suggested Readings

1. Biostatistical Analysis: Zar, J. H. — Pearson
2. Introduction to the Practice of Statistics: Moore, D. S., McCabe, G. P., & Craig, B. A. — W. H. Freeman
3. Bioinformatics and Functional Genomics: Pevsner, J. — Wiley-Blackwell
4. Bioinformatics. Andreas D. Baxevanis (Edited) , David S. Wishart (Edited) , Gary D. Bader (Edited) | Publisher: John Wiley & Sons Inc | Publisher Imprint: John Wiley & Sons Inc
5. Bioinformatics Tools for Pharmaceutical Drug Product Development. Editor(s): Vivek Chavda, Krishnan Anand, Vasso Apostolopoulos
6. Statistics for Biology and Health: Everitt, B. S., &Hothorn, T. — Springer
7. Chen, J.-T. (Ed.). (2026). AI in Plant Science and Precision Agriculture (1st ed.). CRC Press. https://doi.org/10.1201/9781003545781
8. Munir Majdalawieh, Carla Martins, Mohammed Radi, Maher Alaraj, Shafaq Khan,Precision agriculture in the age of AI: A systematic review of machine learning methods for crop disease detection, Smart Agricultural Technology, Volume 12,2025,101491,ISSN 2772-3755,https://doi.org/10.1016/j.atech.2025.101491
9. Russell, Stuart J.; Norvig, Peter (2020), Artificial Intelligence: A Modern Approach (4th ed.), Upper Saddle River, New Jersey: (Pearson Series in Artificial Intelligence).

Specialisation (Elective Paper)

BOT 513

Total marks 20; Credits 2; Class 30 hours

BOT 513A

Advanced Paleobotany and Palynology

Total marks 20; Credits 2; Class 30 hours

Course Outcomes (COs)

I. **Memorizing:**
- Recall the major palaeofloras of the Indian subcontinent (Deccan Intertrappean, Siwalik, and Karewa floras)
- Key palaeobotanical terms, fossil plant groups
- Concepts related to archaeobotany, palaeoethnobotany, and major geological events

II. **Understanding:**
- Explain methods used in palaeoclimate and palaeoenvironmental reconstruction, including the Nearest Living Relative (NLR) method, CLAMP, Co-existence Approach (Co-A), stable isotope analysis ($\delta^{13}C$, $\delta^{18}O$), and atmospheric pCO_2 estimation, and describe their significance in interpreting Earth's past.
- Describe fossil evidence for the evolution of plant physiological and developmental mechanisms, plant–animal interactions, the evolution and expansion of C_4 and CAM plants
- The impact of mass extinctions, PETM, K–Pg boundary events, palaeotempestology, and palaeofire records on vegetation history.

III. **Applying:**
- Apply palaeobotanical, palynological, isotopic, and archaeobotanical evidence to interpret past vegetation, climatic conditions, depositional environments, fire history, and the origin and development of agriculture and ancient plant economies in India.

Programme Outcomes (POs)

Students will develop a sound understanding of palaeobotany and palynology, apply scientific methods to reconstruct past environments and plant evolution, strengthen analytical and research skills, communicate scientific findings effectively, and promote ethical practices and lifelong learning in Earth and plant sciences.

Syllabus

1. **Palaeofloristics of Indian subcontinent:** Brief knowledge of Deccan intertrappean, Siwalik and Karewa floras
2. **Some methods and approaches of past depositional environment/climate reconstructions:** Nearest living relative (NLR) method, Climate Leaf Analysis Multivariate Program (CLAMP), Co-existence approach (Co-A), stable isotopes ($^{\delta}$13C, $^{\delta}$18O) and pCO2 conc.

3. **Fossil evidence of physiological, developmental mechanisms and biotic interactions:** evolution of C4 and CAM photosynthetic pathways in plants; Miocene expansion of C4 grasses and probable causes; evolution of grasses and grazers; polar auxin flow;Plant-animal interaction and their co-evolution in the fossil record

4. **Brief concept of past extreme events:** Mass extinctions through geological time; floral change-over across the Palaeocene-Eocene thermal maxima (PETM) and Cretaceous-Tertiary boundary; Detection of tropical cyclones and tsunamis in the geological past (Palaeotempestology); past fire and environmental change; charcoal as information source in reconstructing fire history

5. **Archaeobotany and palaeoethnobotany:** Origin and development of agriculture in India; study of ancient plant economy (cereals, pulses, fruits and drugs plants) from Palaeolithic to Historic age of India; archaeopalynology in analysis of prehistoric vegetation and human/animal diet

Suggested Readings:

1. Cleal, C. J., Thomas, B.A. 1999. Plant Fossils. The History of Land vegetation. Woodbridge Boydell Press, Woodbridge, VA.
2. Krings, Michael et al., 2018.Transformative palaeobotany
3. Levin, H. L. 1981. Contemporary Physical geology.
4. Scott, A. C., et al., 2014. Fire on Earth: An Introduction. Willey Blackwell Publ.
5. Senger, R. 1999. Encylopedia of Palaeontology. Fitzroy Dearborn Publ.
6. Taylor, T.N., Taylor, E.L., Krings, M. 2009. Palaeobotany-The Biology and Evolution of Fossils Plants. Elsevier.
7. Willis, K. J., McElwain, J.C. 2002. The Evolution of Plants. Oxford University Press, New York.
8. Traverse, A. 1988. Palaeopalynology

BOT 513B

Advanced Phycology

Total marks 20; Credits 2; Class 30 hours

Course Outcomes (COs)

Understanding

- Designing sustainable, innovative, and interdisciplinary biotechnological strategies using algal resources for environmental, industrial, and societal applications while adhering to ethical and regulatory principles.

Memorizing

- The principles and applications of molecular markers and genomic tools for the identification, classification, phylogeny, and diversity assessment of algae.
- Algal biorefinery concepts and circular bioeconomy approaches for sustainable production of biofuels, biomaterials, nutraceuticals, and value-added products.

Applying

- Carbon sequestration, carbon credit estimation, climate change mitigation, and the concept of "Algae Tree" for environmental sustainability.
- The potential of algal cells as nanobiotechnology platforms for the production of biofuels, bioplastics, metal nanoparticles, biosensors, and other industrially important biomolecules.
- Machine learning (ML), artificial intelligence (AI), and bioinformatics tools for algal biotechnology, omics data analysis, predictive modelling, and bioprocess optimization.

Programme outcome (PO)

Upon completion of the syllabus, students will be able to demonstrate comprehensive knowledge of plant and algal sciences, integrating classical and modern biological concepts and utilize AI, machine learning, computational biology, databases, and digital technologies for entrepreneurial ventures in agriculture, biotechnology, and environmental sectors.

Syllabus

1. Application of Molecular Markers in an algal diversity study

2. Algal Biorefinery and circular bio economy

3. Application of algae in carbon credit estimation: Algae tree

4. Algal cell as a nano bio factory: liquid fuel cell, bioplastics, metal nanoparticle production

5. Machine learning (ML) Algorithms and AI for biotechnological applications.

Suggested Readings

1. Cyanophyta : T.V. Desikachary –ICAR
2. Taxonomic classification of Cyanoprokaryotes -Komarek et al.-Presila 86:295-335,2014
3. Frederik Leliaert , David R. Smith , Hervé Moreau , Matthew D. Herron ,Heroen Verbruggen , Charles F. Delwiche & Olivier De Clerck (2012) Phylogeny andMolecular Evolution of the Green Algae, Critical Reviews in Plant Sciences, 31:1, 1-46, DOI:10.1080/07352689.2011.615705
4. G. M. Smith, "The Fresh Water Algae of United States," McGraw Hill Book Company, New York, USA, 1950.
5. Dr.Debabrata Das Algal Biorefinery: An integrated Approach. Springer
6. Linda E.Graham, James M.Graham,Lee.W.Wilcox (Benjamin Cummin); Algae
7. Barsanti, L., & Gualtieri, P. (2014). Algae: Anatomy, Biochemistry, and Biotechnology (2nd ed.). CRC Press.
8. Richmond, A., & Hu, Q. (Eds.). (2013). Handbook of Microalgal Culture: Applied Phycology and Biotechnology (2nd ed.). Wiley-Blackwell.

9. Singh, J. S., & Dhar, D. W. (Eds.). (2023). Algal Green Chemistry: Recent Progress in Biotechnology. Elsevier.
10. Borowitzka, M. A., Beardall, J., & Raven, J. A. (Eds.). (2016). The Physiology of Microalgae. Springer.
11. Rosenberg, J. N., Oyler, G. A., & Betenbaugh, M. J. (Eds.). (2023). Microalgae Biotechnology for Development of Biofuel and Wastewater Treatment. Springer.

BOT 513C

Analytical Techniques

Total marks 20; Credits 2; Class 30 hours

Course outcomes (CO)

I. Understanding

- Conceptual knowledge generation in molecular cloning, PCR, vector selection, and recombinant DNA technology.
- DNA–protein interaction methods: yeast one-hybrid, ChIP, EMSA, DNase footprinting, and molecular beacons.
- incorporation methods of radioisotopes into biomolecules and tissues, and interpret autoradiograms.

II. Memorizing

- Roles and specificities of exonucleases and endonucleases in cloning and DNA repair.
- Design, implement, and validate gene-editing experiments (gRNA design, CRISPR systems, mutant screening), and assess agricultural applications and regulations.
- Safely conduct radiolabeling experiments, analyse autoradiography data, and follow radiation safety and waste-management protocols.

III. Applying

- Analyse and interpret molecular biology and interaction data, sequencing results, and autoradiographs.
- Interpret assays for biomolecular interactions (protein–protein, protein–DNA/RNA) using biochemical and imaging methods.

Programme Outcomes (POs)

Upon completion of this course, students will be able to assess agricultural applications, regulatory frameworks, biosafety, and ethical implications of genome editing and get Knowledge about biosafety and radiation safety.

Syllabus

1. Molecular breeding techniques: Primer design principles for gene cloning and amplification, PCR methodologies: conventional, qPCR, multiplex PCR, and high-fidelity/long-range PCR, Vector selection criteria and delivery considerations for cloning and expression, cloning strategies:

TA cloning, directional cloning, Gateway cloning, Golden Gate assembly, and Gibson assembly. Analysis of recombinant constructs, Exonucleases and endonucleases: types, specificities, and roles in cloning, genome manipulation, and DNA repair.

2. Detection of biomolecules interaction: Protein-protein interaction by yeast two-hybrid assay, bimolecular fluorescence complementation, FRET, Co-immunoprecipitation, pull-down assay, DNA-protein interaction by yeast one-hybrid assay, ChIP, EMSA, DNAase footprinting, Molecular Beacon, RNA protein interaction and aptamers

3. Gene editing techniques: Fundamentals of gene editing techniques and repair pathways, Guide RNA (gRNA) design, assembly strategies, and in-silico analysis. CRISPR–Cas9 vector systems, Alternative CRISPR effectors (Cas12, Cas13 and other Cas enzymes) and their applications, screening and validation of gene-edited mutants. Application in Agriculture for trait improvement, regulatory considerations, biosafety, and ethical issues

4. Radiolabeling techniques: Detection and measurement of different types of radioisotopes used in biology, incorporation of radioisotopes in biological tissues and cells, autoradiography, Effect of radioisotopes, doses, and safety guidelines

Suggested Readings

1. Molecular Biotechnology by Primrose
2. Molecular Cell Biology, Lodish H et al., - Freeman
3. Cell and Molecular Biology, De Robertis and De Robertis – Lippincott and Wilkins
4. Recombinant DNA: Genes and Genomes, A Short Course – Watson JD et al.-Macmillan
5. Molecular Biotechnology: Principles and Applications of Recombinant DNA, Glick BR et al.-
6. Analytical techniques in Biochemistry and molecular biology by Rajan Katoch

BOT 513D
Applied Virology
Total marks 20; Credits 2; Class 30 hours

Course outcomes (CO)

I. Understanding

- The principles of virus-like particles (VLPs), their production strategies, structural characteristics, and applications in vaccine development and diagnostics.
- The use of viruses as vectors in biotechnology, including applications in gene therapy, gene editing, vaccine delivery, and RNA interference (gene silencing).

II. Memorizing

- The use of viruses as vectors in biotechnology, including applications in gene therapy, gene editing, vaccine delivery, and RNA interference (gene silencing).

III. Applying

- Developing an understanding of current advances in antiviral drug discovery, recombinant technologies, vaccine development, and translational virology for applications in biomedical research, public health, and pharmaceutical biotechnology.

Programme Outcome

Upon completion of the syllabus, the students will be able to acquire advanced knowledge of microbiology, virology, molecular biology, biotechnology, genetics, and immunology to understand viral diversity, host–virus interactions, disease mechanisms, and therapeutic interventions.

Syllabus

1. Introduction to Virus-Like Particles (VLPs) production strategies and applications.

2. Baculovirus protein expression system, application and importance.

3. Virus as vectors: gene therapy to gene silencing

4. Antiviral strategies for Direct-Acting Antivirals (DAA)

5. Conventional vaccines -killed and attenuated, modern vaccines— designing and production strategies for recombinant proteins, subunits, DNA vaccines, peptides, vaccine delivery and adjuvants,

6. Interferons, designing and screening for antivirals, mechanisms of action, antiviral libraries, antiretrovirals-mechanism of action and drug resistance.

Suggested Readings

1. Antiviral Agents, Vaccines, and Immunotherapies. Stephen K. Tyring. 2004. Publisher: Marcel Dekker.
2. Antiviral Drug Discovery for Emerging Diseases and Bioterrorism Threats. Paul F. Torrence (Editor). July 2005. Publisher: Wiley, John & Sons, Incorporated.
3. Chimeric Virus -like Particles as Vaccines. Wolfram H. Gerlich (Editor), Detlev H. Krueger (Editor), Rainer Ulrich (Editor). November 1996 Publisher: Karger, S. Inc.
4. Vaccines. Stanley A. Plotkin, Walter A. Orenstein. September 2003. Publisher: Elsevier Health Sciences.
5. Retroviruses. Coffin JM, Hughes SH, Varmus HE, editors. Cold Spring Harbor (NY): Cold Spring Harbor Laboratory Press; 1997. (Available on NCBI)
6. Baculovirus Molecular Biology [Internet]. 3rd edition. Rohrmann GF. Bethesda (MD): National Center for Biotechnology Information (US); 2013. (Available on NCBI)
7. New Vaccine Development Establishing Priorities: Volume II: Diseases of Importance in Developing Countries. Institute of Medicine (US) Committee on Issues and Priorities for New Vaccine Development. Washington (DC): National Academies Press (US); 1986. (Available on NCBI)

BOT 513E
Bryophytes
Total marks 20; Credits 2; Class 30 hours

Syllabus

1. Brief concepts of Embryophytes, Archegoniates and Monosporangiophyta, Different Modes of Vegetative Reproduction among Bryophytes, Apical cell diversity in Liverworts, Chloroplast diversity in Hornworts, Gametophyte diversities and leaf diversities in Liverworts; Leaf and calyptra diversities in Mosses

2. Life strategies and different growth forms (Growth forms and Life forms), Substratum ecology, Biochemical and molecular mechanisms of desiccation tolerance in bryophytes

3. Conservation biology among bryophytes, Peristome structure and its significance in the classification of mosses, including how to write peristome formula

4. Fossil Bryophytes: Rarity of fossil bryophytes; Brief idea of Indian fossil bryophytes.

Suggested Readings

1. Shaw, A. J. & Goffinet, B. (Eds.). Bryophyte Biology (3rd ed., Cambridge University Press, 2022).
2. Vanderpoorten, A. & Goffinet, B. Introduction to Bryophytes (Cambridge University Press, 2009).
3. Glime, J. M. Bryophyte Ecology (online reference).
4. Taylor, T. N., Taylor, E. L. & Krings, M. Paleobotany: The Biology and Evolution of Fossil Plants (2nd ed., Academic Press, 2009).
5. Parihar, N. S. An Introduction to Embryophyta, Vol. I: Bryophyta (Central Book Depot).

BOT 513F
Cell Fate and Dynamics

Total marks 20; Credits 2; Class 30 hours

Course Outcomes (COs)

I. Understanding

- The structure, composition, and physiological significance of different cell junctions (tight junctions, adherens junctions, and gap junctions) and explain the functions of junctional proteins in cell-cell communication and tissue organization.

II. Memorizing

- The phases of the cell cycle, the molecular mechanisms regulating cell cycle progression, checkpoints, and mechanisms controlling cell division and cell cycle exit.
- The major types of programmed and non-programmed cell death (apoptosis, autophagy, and necrosis) and evaluate the role of key regulatory proteins in maintaining cellular homeostasis.

III. Applying

- The major types of programmed and non-programmed cell death (apoptosis, autophagy, and necrosis) and evaluate the role of key regulatory proteins in maintaining cellular homeostasis.
- Integrate knowledge of cell cycle regulation, cell death, cell adhesion, and signalling pathways to interpret cellular processes involved in growth, development, immunity, and disease.

Programme Outcome (PO)

Upon completion of the syllabus, students will be able to learn comprehensive knowledge of plant sciences and allied biological disciplines, integrating concepts from cell biology and molecular biology and apply biological knowledge and technical expertise in research organizations, academia, biotechnology industries, healthcare, environmental management, and entrepreneurial ventures.

Syllabus

1. Cell cycle: Cell cycle- different phases, regulation and checkpoints to control cell division and exit.

2. Cell death: Brief idea about apoptosis, autophagy, and necrosis, the role of relevant proteins.

3. Cell-cell interaction: Different types of junctions (tight junction, adhesion junction and gap junctions), structure and function; junctional protein types, structure and role in junction.

4. Cell signalling: Types of receptors, different signalling molecules, transduction pathways and examples.

Suggested Readings

1. Molecular Biology of the Cell. Bruce Alberts, Rebecca Heald, Alexander Johnson, David Morgan, et al. 7th Edition.
2. Molecular Cell Biology. Harvey Lodish, Arnold Berk, et al. 9th Edition. W.H. Freeman, 2021.
3. The Cell: A Molecular Approach. 9th Edition. Oxford University Press, 2023.
4. The World of the Cell- Becker WM et al,- Benjamin Cummings

BOT 513G

Chemistry and Biology of Plant Natural Products

Total Marks- 20; Credit-2; Class 30 hours

Course Outcomes (COs)

I. Understanding

- The structure, functions, and therapeutic significance of enzymes, amino acids, proteolytic enzymes, ribosome-inactivating proteins (RIPs), and lectins as plant-derived drugs.
- Knowledge of medicinal plants, phytochemicals, proteins, enzymes, and biotechnology.

II. Memorizing

- The pharmacological properties and mechanisms of action of important plant drugs exhibiting antitumor, hypoglycaemic, antihepatotoxic, antiprotozoal, antiviral, antioxidant, and phytoestrogenic activities.
- Principles of plant tissue culture and biotechnology for the production and enhancement of valuable secondary metabolites.

III. Applying

- Analyze the applications of microbiological transformation, metabolic engineering, and biotechnological interventions in phytopharmaceutical production.
- Design and conduct experiments related to medicinal plant biotechnology and drug discovery.

Programme Outcomes (POs)

Upon completion of this course, students can analyze the applications of microbiological transformation, metabolic engineering, and biotechnological interventions in phytopharmaceutical production and assess the potential of modern biotechnology in developing sustainable and commercially viable medicinal plant products.

Syllabus

1. Phytochemistry, biosynthesis and sources of drugs: Phenolic glycosides, coumarins, furanocoumarins, flavonoid glycosides, steroids, sterols, stanols, steroidal glycosides, cucurbitacins and related compounds, iridoids, tetraterpenoids, polyterpenoids, organo-sulphur compounds and others

2. Secondary metabolism: Turnover and degradation of secondary metabolites – physiological and developmental aspects; compartmentation of secondary metabolism

3. Enzymes, Proteins amino acids as drugs: Proteolytic enzymes, Ribosome inactivating Proteins (RIPs), Lectins

4. Pharmacological action of plant drugs: Tumour inhibitors, hypoglycaemic, antihepatotoxic, antiprotozoal, antiviral, PAF anatagonists, antioxidants, phytoestrogens, enzyme inhibitors

5. Tissue culture and biotechnology for production of secondary metabolites -microbiological conversion, metabolic engineering.

Suggested Readings

1. Trease and Evans Pharmacognosy – Medicinal plants and plant drugs.
2. Kokate's Pharmacognosy – Easy-to-understand pharmacognosy concepts.
3. Lehninger Principles of Biochemistry – Enzymes, proteins, and amino acids.
4. Bhojwani & Razdan – Plant Tissue Culture: Theory and Practice – Tissue culture techniques.
5. Introduction to Plant Biotechnology (Chawla) – Biotechnology fundamentals.
6. Rang and Dale's Pharmacology – Pharmacological actions and mechanisms.
7. Ramawat & Mérillon – Biotechnology of Medicinal Plants – Secondary metabolite production and metabolic engineering.

BOT 513H
Fungal molecular systematics
Total marks 20; Credits 2; Class 30 hours

Course Outcomes (COs)

I. Understanding

- Bioinformatics tools and fungal databases integrate data through polyphasic taxonomy

II. Memorizing

- Fungal classification and nomenclature apply molecular markers, ribosomal DNA regions (ITS, LSU, SSU), and DNA barcoding for fungal identification, and perform phylogenetic analyses.

III. Applying

- Fungal systematics in biodiversity, conservation, agriculture, medicine, and biotechnology.

Program Outcomes (POs)

Students completing this course will be proficient in fungal molecular systematics, classification, nomenclature, and the International Code of Nomenclature. They will develop skills in molecular markers, ribosomal DNA regions, DNA barcoding, phylogenetic analyses, polyphasic taxonomy,

bioinformatics tools, and fungal databases for accurate fungal identification and classification with applications in biodiversity, conservation, agriculture, medicine, and biotechnology.

Syllabus

1. Traditional and modern classification approaches.

2. The International Code of Nomenclature for Algae, Fungi, and Plants; Proposals on fungal nomenclature.

3. Molecular markers in fungal taxonomy; Ribosomal DNA regions (ITS, LSU, SSU); DNA barcoding and fungal identification.

4. Principles of molecular phylogenetics; Construction and interpretation of phylogenetic trees.

5. Polyphasic taxonomy; Bioinformatics tools and fungal databases.

6. Applications of fungal systematics in biodiversity studies, conservation, agriculture, medicine, and biotechnology.

Suggested Readings

1. Introduction to Fungi – Webster & Weber
2. The Fungi – Watkinson, Boddy & Money
3. International Code of Nomenclature for Algae, Fungi, and Plants
4. Molecular Systematics – Hillis, Moritz & Mable
5. Phylogenetic Trees Made Easy – Barry Hall
6. Bioinformatics and Functional Genomics – Pevsner

BOT 513I
Genetic and Epigenetic Perspectives of Plant Development
20 marks; 2 credits; Class 30 hours

Course outcome (CO)

I. Understanding

- Foundational plant developmental genetics to evaluate gene regulatory networks and loops controlling key developmental pathways, hormonal cross-talk and homeotic identities.

II. Memorizing

- Major genes and transcription factors controlling morphogenetic cascades and gametophytic development; understanding genetic mechanisms controlling fertilization and post-fertilization changes.

III. Applying

- The concept of fluidity of the plant epigenetic landscape, tracking integration of environmental cues with epigenetic changes, and exploring the concept of transgenerational epigenetic memory in plants

Programme Outcome (PO):

Students will demonstrate a comprehensive understanding of plant developmental genetics and epigenetics by integrating knowledge of gene regulatory networks, embryogenesis, organogenesis, meristem maintenance, hormonal regulation, epigenetic modifications, and environmental responses to analyze plant growth, development, phenotypic plasticity, and adaptation, thereby enabling them to undertake advanced research and contribute to sustainable crop improvement and modern plant biotechnology.

Syllabus

1. Foundational developmental genetics: Embryogenesis and Polarity: Genetic networks establishing the apical-basal axis, radial patterning, and asymmetric cell division. Meristem Identity and Maintenance: Regulatory loops governing the Shoot Apical Meristem (SAM) and Root Apical Meristem (RAM), focusing on the WUSCHEL-CLAVATA pathway. Organogenesis and Homeotic Identity. Genetic pathways controlling hormonal cross-talks during structural differentiation.

2. Creating the plant structural blueprint: Major transcriptional factors and gene families involved in plant development; Morphogenetic cascades in plant life cycle; Homeotic genes and mutants in plant development; Major gene regulatory networks involved. Genetic regulation of gametophyte development, fertilization and post-fertilization changes.

3. The Plant Epigenetic Landscape as a fluid regulatory layer: Factors controlling the plant epigenetic landscape; Epigenetic regulation of key plant developmental pathways and phase changes; Epigenetic resetting during gametogenesis; Genome imprinting; small/microRNA control over developmental phase transitions; long non-coding RNA and plant development

4. Environmental Integration and Phenotypic Plasticity: Epigenetic control of Nutrient allocation; Epigenetic memory locking and Vernalization; Stress Memory and Epialleles. Transgenerational Epigenetic Inheritance: rules governing the escape from germline resetting and the passing of environmental "memories" to subsequent generations.

Suggested Readings

1. Nikolaus Rajewsky, Stefan Jurga, Jan Barciszewski (Eds.) Plant Epigenetics (series: RNA Technologies). Springer Cham. https://doi.org/10.1007/978-3-319-55520-1

2. Developmental Biology of Flowering Plants, Raghavan (2000) - Springer

3. Quentin C.B. Cronk, Richard M. Bateman, Julie A. Hawkins (Eds.) (2002) Developmental Genetics and Plant Evolution- CRC Press. ISBN 9780415257916

4. Doug Soltis, Pamela Soltis, Jim Leebens-Mack (Eds.) (2006) Developmental Genetics of the Flower: Advances in Botanical Research. Volume 44st Edition. Academic Press. ISBN: 9780120059447.

BOT 513J
Immunology

Total marks 20; Credits 2; Class 30 hours

Course Outcomes (CO):

I. Understanding

- The cellular and molecular mechanisms underlying innate and adaptive immune responses
- The immunological basis of infectious diseases, immunodeficiencies, hypersensitivity, and autoimmune disorders.

II. Memorizing

- Antigen recognition, immune regulation, and host–pathogen interactions in health and disease
- The molecular mechanisms involved in cancer initiation, progression, metastasis, and therapeutic interventions

III. Applying

- Advanced immunological and molecular techniques such as Flow Cytometry, ELISA, FISH, GISH, and immunoprecipitation in research and diagnostics.
- Design research strategies integrating immunology, cancer biology, and biotechnology for addressing contemporary biological and biomedical challenges

Programme Outcomes (POs)

Upon successful completion of this course, students will be able to demonstrate professional competencies required for careers in healthcare, biotechnology, biomedical industries and research by designing strategies integrating immunology and biotechnology for addressing contemporary biological and biomedical challenges**.**

Syllabus

1. Fundamentals of Immunology: Organization and functions of the immune system, Cells and molecules involved in innate and adaptive immunity, Antigens, antigenicity, immunogenicity, haptens, and adjuvants, B-cell and T-cell epitopes, Structure, classes, and biological functions of immunoglobulins.

2. Immune Response and Regulation: Major Histocompatibility Complex (MHC): structure and functions, Antigen processing and presentation pathways, B Cell Receptor (BCR) and T Cell Receptor (TCR): structure and signalling mechanisms, Complement system and its biological significance, Pattern recognition receptors (PRRs) and Toll-like receptors (TLRs), cell-mediated effector functions.

3. Immunopathology: Inflammation, hypersensitivity and autoimmunity, Immune response during bacterial (tuberculosis), parasitic (malaria) and viral (HIV) infections, congenital and acquired immune deficiencies, vaccines

4. Vaccines and Immunization: Principles of vaccination, Conventional and next-generation vaccines, Plant-based vaccines and edible vaccines, Applications of immunization in public health.

5. Cancer Biology: Genetic rearrangements in progenitor cells, oncogenes, tumor suppressor genes, cancer and the cell cycle, virus-induced cancer, metastasis, interaction of cancer cells with normal cells, apoptosis, therapeutic interventions of uncontrolled cell growth.

6. Advanced Techniques in Immunology and Biomedical Sciences: Flow cytometry and its application in biomedical sciences, detection of molecules in living cells, in situ localization by techniques such as FISH and GISH, Immunosorbent Electron Microscopy. Detection of molecules using ELISA, RIA, and immunoprecipitation.

7. Cell culture techniques- mammalian cell culture techniques, stem cell culture, iPSCs, organoids and spheroids culture

Suggested Readings

1. Kuby Immunology – Core immunology

2. Cellular and Molecular Immunology (Abbas) – Clinical immunology and vaccines

3. The Biology of Cancer (Weinberg) – Cancer biology

4. Culture of Animal Cells (Freshney) – Cell culture, stem cells, organoids

BOT 513K
Molecular Biology of Plants

Marks 20, credit 2; Syllabus; Class 30 hours

Course outcome (CO)

I. Understanding

- The biosynthesis, labelling, and detection of plant hormones, nucleotides, amino acids, nucleic acids, and proteins using both in vitro and in vivo approaches.
- The mechanisms of signal perception, signal transduction, and hormonal integration regulate plant growth, development, reproduction, senescence, and programmed cell death.

II. Memorizing

- The thermodynamic principles governing biological systems, molecular interactions, binding kinetics, and energy transformations.

II. Applying

- Biochemical and biophysical techniques for the detection, separation, isolation, characterization, and analysis of biomolecules.

Programme Outcome (PO)

Graduates will acquire an integrated understanding of plant biochemistry, molecular biology, and physiology to analyze biomolecular interactions, metabolic pathways, and signalling networks, enabling them to apply advanced experimental approaches in plant research, biotechnology, and sustainable crop improvement.

Syllabus

1. Thermodynamic rules in biological system, Binding energy and kinetics, Binding process in biology.

2.Detection of biological molecules, separation and isolation of biomolecules, identifying the composition of biomolecules, Absorption and emission of light by biomolecules, interaction between biomolecules.

3. Biosynthesis of hormones, nucleotides and amino acids in plants, labelling and detection of hormones, nucleic acids, and proteins (both *in vitro* and *in vivo*)

4. Signal perception, transduction and integration in plants with respect to plant hormones.

5. Molecular regulation of reproductive development, senescence and cell death.

Suggested Readings

1. Biochemistry and molecular biology of plants Buchanan, Gruissem and Russel
2. Molecular biology: Principles and genome function Craig Nancy et al
3. The physical and chemical basis of molecular biology, TE Creighton
4. Molecular biology and biotechnology edited by Walker and Raply
5. Advanced Molecular Biology Richard Twyman Garland Science
6. Cell and Molecular Biology De Robertis and De Robertis Lippincott and Wilkins
7. Molecular Cell Biology Lodish H et al. Freeman
8. Molecular biology of the cell, Alberts B et al Garland

BOT 513L
Molecular Stress Biology

Total marks 20; Credits 2; Class 30 hours

Course outcome (CO)

I. Understanding

- The roles of stress-responsive genes, transcription factors (ERF, bZIP, WRKY), and GCC-box-containing genes in plant adaptation to biotic and abiotic stresses.
- The molecular mechanisms of stress perception, signal transduction, and defense activation mediated by salicylic acid, jasmonic acid, ethylene, and abscisic acid pathways.

II. Memorizing

- Morphological and anatomical adaptations of plants to environmental stresses, including xerophytic, hydrophytic, halophytic, thermal, and pathogen-induced adaptations.
- The roles of pattern recognition receptors, PTI, ETI, stomatal defense mechanisms, trichomes, and guard-cell signaling in plant immunity.

III. Applying

- Knowledge of plant defense signaling networks to understand interactions between stress responses and crop adaptation.
- Design strategies for improving crop resilience using molecular, genetic, and biotechnological approaches for sustainable agricultural production.

Programme Outcome (PO)

Upon completion of the syllabus, the students will be able to analyze complex stress-response networks and develop scientific solutions to agricultural challenges and Apply experimental, molecular, physiological, and computational approaches to investigate plant stress responses.

Syllabus

1. Abiotic and biotic stress inducible genes and transcription factors

Ethylene-responsive-element-binding factors (ERF), stress signaling via ERFs, Basic-domain leucine-zipper (bZIP) and role in defence briefly, WRKY proteins: What are WRKY proteins, role in defence briefly, GCC box–containing stress response genes.

2. Signal transduction pathways: salicylic acid mediated signal transduction pathway, Jasmonic acid/Ethylene mediated pathway, ABA-dependent and ABA independent pathways

SA: Brief history, Synthesis pathways (ICS and PAL mediated pathways), role of SA in plant stress defense, Role of SA in NPR1 monomerization, Role of SA in defense gene regulation, Systemic acquired resistance

JA: History of JA, Role of JA, JA derivatives, JA synthesis pathway, JA signalling and receptors/repressors (JA, COI1, JAZ, NINJA, TPL etc.), JA signal transmission/regulation with special reference to JAR1 (JA response 1), (COI1, JAZ)

ABA: History of ABA, ABA dependent and ABA independent pathways, steps of ABA synthesis (in plastid and cytosol), Regulation of ABA, ABA catabolism/removal/degradation in plants

3. Morphological and anatomical adaptations to stresses:

Adaptations to abiotic stresses: xerophytic, hydrophytic, halophytic, thermal adaptations. Adaptations to biotic stresses mechanical barriers, structural and symbiotic adaptations.

4. Role of surface structures and receptors in detecting stresses: Pattern recognition receptors, Role of plant recognition receptors in relation to PTI and ETI, Trichomes in plant disease development and plant defence, Stomata as entry points of pathogens, defence regulation in guard cells, SA and ABA mediated stomatal regulation.

5. Modern technology for improvement of stress tolerance in crop plants: Transgenic approach, genome editing for stress tolerance, and defence-related microRNA.

Suggested Readings

1. Plant Stress Physiology – Sergey Shabala

2. Biochemistry and Molecular Biology of Plants – Buchanan, Gruissem & Jones

3. Plant Hormones: Biosynthesis, Signal Transduction, Action! – Peter J. Davies

4. Plant Immunity: Methods and Protocols – Kemmerling & Parker

BOT 513M

Taxonomy and Biosystematics

Total marks 20; Credits 2; Class 30 hours

Course Outcomes (COs)

I. Understanding:

- Comprehensive knowledge of plant diversity, taxonomy, systematics, evolution, and biodiversity conservation.
- Taxonomic, anatomical, palynological, and evolutionary evidence for classification and phylogenetic relationships.

II. Memorizing

- The historical development of plant taxonomy in India and evaluate the contributions of pioneering taxonomists such as William Roxburgh, Nathaniel Wallich, Joseph Dalton Hooker, Charles Baron Clarke, George King, and Kshitindranath Prasad Biswas.
- Pollen morphology, evolution, and palynotaxonomic evidence in understanding phylogenetic relationships among plants.

III. Applying

- Interpret nodal anatomical characters and assess their significance in evolutionary taxonomy and plant classification.
- Apply the principles and provisions of the International Code of Nomenclature (ICN), including nomenclature at generic and suprageneric ranks, hybrid plant nomenclature, and cultivated plant nomenclature (ICNCP).
- Integrate anatomical, palynological, nomenclatural, floristic, and evolutionary data for solving systematic and biosystematic problems.

Programme Outcomes (COs)

After successful completion of this course, students will be able to analyze the floristic regions of the world and describe the composition and vegetation characteristics of major phytogeographical regions of India, including Himalayan, Peninsular, and Desert regions and evaluate the role of the National Biodiversity Authority, biodiversity legislation, and international conventions in biodiversity conservation and management.

Syllabus

1. Plant taxonomy through ages in India: Major contributions of W. Roxburgh, N. Wallich, J. D. Hooker, C. B. Clarke, G. King and K. P. Biswas; Role of field studies in plant systematic; Centers of taxonomic and floristic studies in India; Taxonomic Literature: Categories, brief concept with examples.

2. Floristic regions of the world (Takhtajan, 1987); Floristic Composition of India: description and composition of Himalayan, Peninsular and Desert vegetation. Biodiversity Act, Role of National Biodiversity Authority (NBA) in biodiversity management; CBD and environmental protocols.

3. International Code of (Botanical) Nomenclature (ICN): Provisions at generic and suprageneric ranks. Nomenclature of Hybrid Plants; Nomenclature of Cultivated Plants (ICNCP).

4. Modern trend and Evolutionary taxonomy: Nodal Anatomy: structure, types, evolution and applications. Palynotaxonomy: pollen structure, types and evolution of pollen grains, implications in plant systematics. Concepts of primitive and advanced characters, anagenesis, stasigenesis, cladogenesis, homology, analogy, homoplasy, parallelism and convergence.

Suggested Readings

1. G. Singh – Plant Systematics: Theory and Practice
2. Simpson – Plant Systematics
3. Stace – Plant Taxonomy and Biosystematics
4. Jain & Rao – Handbook of Field and Herbarium Methods
5. Erdtman – Pollen Morphology and Plant Taxonomy
6. Esau – Plant Anatomy
7. Turland et al. – International Code of Nomenclature (ICN)
8. Primack – Essentials of Conservation Biology

BOT 513N
Translational Plant Genetics and Cytogenetic Technologies

20 marks; 2 credits; Class 30 hours

Course outcome (CO)

I. Understanding

- The importance of genome structure and ploidy dynamics in crop evolution using molecular cytogenetic tools.

II. Memorizing

- The differences between gene pools and the commercial impact of self-incompatibility, male sterility, apomixis, and the molecular mechanisms underlying heterosis and inbreeding.

III. Applying

- Formulation of molecular mapping and marker strategies, and design of breeding schemes for stress-resilient plants.

Programme Outcome (PO)

Upon completing the syllabus, students will be able to demonstrate comprehensive knowledge of crop genetics, molecular cytogenetics, genome organisation, breeding systems, and molecular breeding approaches used in crop improvement.

Syllabus

1. Overview of Crop Genetics and Molecular Cytogenetics

Molecular cytogenetic tools for identification and structural analysis of crop genomes, Introgression studies and ploidy detection, Evolutionary significance of ploidy alterations and chromosomal aberrations in crop improvement, Advances in Optical Mapping and Karyotype Evolution.

2. Applied Crop Genetics

Applications of molecular cytogenetics in crop evolution, Alien gene transfer studies, Gene mapping of agronomic traits and crop improvement in wheat, rice, tomato and cotton. Application of transposons in mutagenesis, genome mapping and evolution.

3. Genetic Systems and Breeding Methods

Gene pools (primary, secondary and tertiary), Systems of mating, Breeding methods for sexually, asexually/clonally propagated crops; Relevance of self-incompatibility, male sterility and apomixis. Heterosis: types, genetic and molecular basis; Inbreeding.

4. Molecular Breeding

Molecular DNA markers and mapping populations, construction of high-density maps, QTL mapping, Association mapping. Gene tagging, Marker Assisted Selection (MAS), Bulk Segregation Analysis (BSA), Genomic selection and Genome Wide Association Studies (GWAS). Breeding for biotic and abiotic stresses, and quality traits. Variety development and release of new varieties.

Suggested Readings

1. Bentlee Salinas (2018) Plant Cytogenetics, Breeding and Evolution. Ed-tech Press. ISBN-13 9781788822411

2. Schwarzacher T, Liu Q, Pat Heslop-Harrison JS. Plant Cytogenetics: From Chromosomes to Cytogenomics. Methods Mol Biol. 2023;2672:3-21. doi: 10.1007/978-1-0716-3226-0_1. PMID: 37335467.

3. Sonia Garcia and Tony Heitkan (Eds.) (2023) Plant Cytogenetics and Cytogenomics: Methods and Protocols(2672 Methods in Molecular Biology). Springer-Verlag NY.

BOT-514

Biochemistry and Developmental Physiology

Total Marks- 40; Credit-3; Class 45 hours

Course Outcomes (CO):

I. Understanding

- Comprehensive knowledge of advanced biochemistry and developmental physiology principles.
- Photoreceptor structure and light-induced signalling (phytochromes, cryptochromes, phototropins, UVR8) and photomorphogenic networks (COP1–HY5, PIFs), circadian/epigenetic control of flowering (miR156/172, PRC, FLC), and role of hormones.

II. Memorizing

- Structure/function of PSI, PSII, cyt b6f, and compare C3/C4/CAM regulation.
- NPQ, photoinhibition, oxidative phosphorylation, glyoxylate bypass, and nitrogen assimilation (GS–GOGAT, NR/NiR, nodulation signalling).

III. Applying

- Ramachandran plots, motifs, and folding forces explain folding thermodynamics, chaperone action, and protein disulfide isomerases.
- Modern tools: Use modern laboratory techniques like spectrophotometry, immunoblotting, and phosphoprotein staining effectively.

Programme Outcomes (POs):

Upon completion of this course, students will be able to critically identify, formulate, and analyze complex research questions in plant biochemistry and development using appropriate theoretical and experimental tools. They can design and conduct experiments, including controls, data collection, statistical analysis, and reproducibility measures.

Syllabus

Section-A

Metabolism & Energetics: I. Carbon Assimilation and Metabolism: Molecular architecture, gene regulation, and polypeptide assembly of PSI, PSII, and Cytochrome b6f. Regulation of C3, C4, and CAM pathways and ecological consideration; non-photochemical quenching (NPQ) and photoinhibition mechanisms, structural biochemistry of oxidative phosphorylation complexes; alternative oxidase energetics, Regulation of the glyoxylate bypass, gluconeogenesis, and plastidial ATP synthesis. II. Nitrogen Assimilation: Signalling cascades in legume-rhizobia symbiosis and nodule organogenesis. Nitrate transport and assimilation, Regulation of the GS-GOGAT cycle, nitrate reductase and nitrite reductase.

Section-B

Biophysical Chemistry of Macromolecules: I. Protein chemistry: Torsion angles, steric hindrance, and thermodynamic boundaries of the Ramachandran Plot. Energetic forces driving folding (hydrophobic collapse, hydrogen bonding networks, van der Waals forces), folding funnels, landscape theory, and the mechanistic action of molecular chaperones (Hsp70/Hsp60 systems) and protein disulfide isomerases. II. Carbohydrate Stereochemistry: Ring conformations (chair/boat puckering), anomeric effects, and mutarotation kinetics. Structural chemistry of glycans, inverted sugars, and derivative glycosides.

Section-C

Sensory Photobiology & Flowering: I. Photomorphogenic Signalling: COP1-SPA E3 ubiquitin ligase complexes; HY5/HFR1 transcriptional networks. Phytochrome Interacting Factors (PIFs)-mediated light signalling mechanism, Molecular mechanism of auxin-mediated shade avoidance, and phototropism, phototropin-mediated chloroplast movement, blue-light induced stomatal opening and antagonistic disruption by Abscisic Acid (ABA). Crosstalk between phytochrome and

cryptochrome signalling for hypocotyl elongation and flowering, UVR8 signaling pathway. II. Floral Evocation, Epigenetics & Organogenesis: MicroRNA-mediated (miR156 & miR172 dependent) phase change mechanism, Central clock oscillators and the external coincidence model, Regulation to repress premature flowering, Epigenetic silencing via Polycomb Repressive Complexes (PRC1/PRC2), histone methylation, and DNA methylation during vernalization (FLC locus regulation) and autonomous pathways, Role of Gibberellic acid and ethylene in flowering, Genetic switches in ABCE model and homeodomain transcription factor networks. Floral asymmetry in *Antirrhinum* flowers.

Section-D

Reproductive Physiology & Self-Incompatibility Systems: I. Pollen stigma recognition and Fertilization: Recognition between pollen grain and stigma surface by adhesion and hydration mechanism, ROP GTPase-mediated actin polymerization and exocytosis. Spatial-temporal Ca^{2+} gradients and oscillatory influx networks at the tube apex. Chemotactic movement of pollen tube towards ovule, Brassinosteroid (BR) signalling in modulating apical calcium channels, synergid-mediated chemotropism, ethylene signalling in regulating programmed cell death (PCD) of synergid cell. LURE peptide-mediated signalling, cellular mechanisms of gamete fusion. II. Gametophytic and sporophytic Self-Incompatibility (GSI & SSI): S-RNase-mediated cytotoxic degradation for GSI; metabolic clearance via the pollen-expressed F-box proteins (SLF/SFB), Allele-specific interaction of pollen SCR/SP11 ligands with stigmatic S-receptor kinases (SRK); downstream ARC1 E3 ligase activation and Exo70A degradation blocking pollen hydration. Brassinosteroid and Salicylic acid crosstalk.

Practical

1. Advanced Enzymology and Kinetic Modeling

Studying the time course impact ((0h, 24h, 48h, 72 h) of nitrogen starvation on nitrate reductase activity, Evaluation the affinity of Nitrate Reductase for its substrate and characterize the mechanism of a known metabolic inhibitor.

2. Plant Ecophysiology

Determination of relative water content and spectrophotometric analysis of proline, total sugar from plant samples after exposure to osmotic stress for different time periods.

3. Functional Proteomics, Post-Translational Modifications, and Immunochemistry

Isolation of total proteins from light and dark-grown seedlings and comparative phosphoprotein analysis through Pro-Q Diamond staining, Demonstration of a western blot to identify the protein of interest from the total protein.

Suggested Readings

1. Plant Physiology and Development by Taiz, Moller, Murphy, Zeiger,
2. Biochemistry & Molecular Biology by Buchanon et al.,
3. Book by Cleon W. Ross and Frank B. Salisbury.
4. Biochemistry by Voet and Voet.;

5. Principles of Biochemistry by Lehninger, Cox & Nelson
6. Biochemistry by Lubert Stryer,
7. Biochemistry by Herper,
8. Biochemistry by Lippincott.
9. Biochemical calculation by Segel (Cambridge).
10. Practical Biochemistry by Rodney Boyers.

BOT 515

Plant Biotechnology

Total Marks- 40; Credit-3; Class 45 hours

Course Outcomes (CO):

I. Understanding

- Concepts of plant development, developmental potency, cellular differentiation, morphogenesis, and pattern formation.
- Knowledge of micropropagation techniques, clonal fidelity assessment, embryo culture, endosperm culture, synthetic seeds, and germplasm conservation.

II. Memorizing

- Physiological, biochemical, and molecular mechanisms underlying in vitro organogenesis, somatic embryogenesis, and gametic embryogenesis.
- Molecular mechanisms of Agrobacterium-mediated transformation and methods for transgene detection, expression analysis, and inheritance studies.
- Principles, vectors, and methodologies involved in plant transformation and genetic engineering.

III. Applying

- Techniques of haploid production, protoplast culture, regeneration, and in vitro mutagenesis for crop improvement.
- The role of cell suspension cultures, organ cultures, hairy root cultures, and bioreactors in large-scale production of plant-derived products.

Programme Outcomes (POs)

Upon completion of the programme, students will be able to analyze biological problems and evaluate experimental approaches in plant biotechnology and molecular breeding. It will help to utilize advanced biotechnological tools, molecular markers, bioinformatics resources, genome editing platforms, and analytical techniques.

Syllabus

Section-A

Basic concepts of plant regeneration: I. Major overlapping processes in development: Developmental potency; Cellular plasticity in plants; Determination and differentiation, mechanisms of cellular determination; morphogenetic gradients, cell fate and cell lineages; positional information and pattern development. II. Pathways of *in vitro* morphogenesis: Physiological, biochemical and molecular aspects of *in vitro* organogenesis, gametic and somatic embryogenesis, Important considerations of haploid production, III. Protoplast culture and regeneration with examples, IV. Somaclonal and gametoclonal variations: causes and genetic basis, V. *In vitro* mutagenesis and selection of mutants.

Section-B

Applications of plant cell, tissue and organ cultures: I. Micropropagation: methods and stages, clonal/ genetic fidelity testing, Examples of commercially propagated species; Tissue culture for tree improvement, II. Zygotic embryo and endosperm culture: applications with examples; III. Synthetic seeds; IV. Excised unorganized and organ cultures: establishment and applications; V. Production of natural products by cell suspension cultures, VI. Bioreactors in plant *in vitro* cultures, VII. Micropropagation, shoot and root organ cultures in batch cultures and in bioreactors with examples, VIII. Problems in commercial exploitation plant *in vitro* cultures; IX. Cryopreservation and germplasm conservation.

Section-C

Plant Transformation and Genetic Engineering: I. Plant transformation vectors: T-DNA vectors and viral vectors, Selectable marker genes and reporter genes, II. Methods of transformation: *Agrobacterium*-mediated transformation, Direct gene transfer methods (gene gun, electroporation, PEG-mediated, etc.), In planta transformation, Chloroplast transformation, III. Molecular mechanism of *Agrobacterium-mediated* transformation, IV. Detection of Transgene, identification of integration site, determination of copy number, inheritance of transgene, transgene expression, and silencing, V. Marker-free and novel selection strategies, VI. Genome editing for crop improvement (CRISPR-Cas9).

Section-D

Applications of Plant Transgenic Technology: I. Overview of Genetically Modified (GM) Crops: Definition and classification, Major GM crops and traits (e.g., Bt crops, herbicide tolerance), Global adoption and current status, II. Transgenic crops for: Resistance to biotic and abiotic stresses, III. Engineering traits: Male sterility, Flowering and flower colour, Fruit ripening and senescence, IV. Nutritional improvement: Biofortification, V. Molecular farming and production of pharmaceuticals, VI. Metabolic engineering and secondary metabolite production, VII. Hairy root culture systems, VIII. Biosafety, regulation, and ethical considerations of GM crops.

Practical

1. Basic techniques for establishment of aseptic plant tissue culture
2. Study effects of phytohormones on *in vitro* morphogenesis
3. Study of stages of micropropagation using shoot tip/nodal buds
4. Study of callus and cell suspension cultures; induction of somatic embryogenesis
5. Preparation of constructs and competent cells for *Agrobacterium-mediated* transformation]
6. *Agrobacterium-mediated* transformation in *Nicotiana*

Suggested Readings

1. Plant propagation by Tissue Culture Volume 1 George, Edwin F., Hall, Michael A., De Klerk, Geert-Jan (Eds.), (Springer 2008)
2. Plant Tissue Culture: Theory and Practice by SS Bhojwani and MK Razdan. Elsevier.
3. Plant Cell Tissue and Organ Culture: Fundamental Methods by OL Gamborg and GC Phillips. Naropsa.
4. Principles of Gene Manipulation by Primrose and Twyman, Wiley–Blackwell Publishers
5. Molecular Biotechnology: Principles and Applications of Recombinant DNA: Glick, B. R., Pasternak, J. J., & Patten, C. L. — ASM Press

BOT 516

Combined Practical Paper-III

Total Marks- 40; Credit-3

Syllabus: Prescribed practical as mentioned in Papers BOT 514 and 515

4th Semester

BOT 521

Dissertation

Total Marks- 150; Credit-12; Class 180 hours

BOT 522

Grant Writing

Total Marks- 50; Credit-4; Class 60 hours

BOT 523

Review Writing

Total Marks- 50; Credit-4; Class 60 hours