

GU/Acad –PG/BoS -NEP/2025-26/240

Date: 09.07.2025

CIRCULAR

The Academic Council & Executive Council of the University has approved Ordinance OA-35A relating to PG Programmes offered at the University campus and its affiliated Colleges based on UGC 'Curriculum and Credit Framework for Postgraduate Programmes'. Accordingly, the University has proposed introduction of Ordinance OA-35A from the Academic year 2025-2026 onwards.

The Programme structure and syllabus of Semester I and II of the **Master of Science in Botany** Programme approved by the Standing Committee of the Academic Council in its meeting held on 24th & 25th June 2025 is attached.

The Dean & Vice-Dean (Academic) of the School of Biological Sciences and Biotechnology are requested to take note of the above and bring the contents of the Circular to the notice of all concerned.

(Ashwin V. Lawande)
Deputy Registrar – Academic

To,

1. The Dean, School of Biological Sciences and Biotechnology, Goa University.
2. The Vice-Dean (Academic), School of Biological Sciences and Biotechnology, Goa University.

Copy to:

1. Chairperson, BoS in Botany, Goa University.
2. Programme Director, M.Sc. Botany, Goa University.
3. Controller of Examinations, Goa University.
4. Assistant Registrar Examinations (PG), Goa University.
5. Director, Directorate of Internal Quality Assurance, Goa University for uploading the Syllabus on the University website.

GOA UNIVERSTIY
MASTER OF SCIENCE IN BOTANY
(Effective from Academic Year 2025-26)

ABOUT THE PROGRAMME

M.Sc. in Botany is a postgraduate degree programme that offers advanced study and specialization in the field of Plant Sciences. The course is designed to provide in-depth knowledge of various aspects of Botany, including Plant Systematics, Ecology, Developmental Biology, Physiology, Cell and Molecular Biology, Genetics, Biotechnology, and Environmental Science. The programme combines theoretical learning, practical training, fieldwork, and independent research.

Eligibility: Graduate in Botany.

OBJECTIVES OF THE PROGRAMME

1. To provide knowledge of Plant Sciences and develop scientific and research skills.
2. To train students in laboratory techniques, fieldwork, and data analysis for ecological and biotechnological applications.
3. To foster awareness of environmental sustainability and biodiversity conservation.
4. To prepare students for careers in teaching, Research, Entrepreneurship, industry, and higher education.

PROGRAMME SPECIFIC OUTCOMES (PSOs)

PSO 1.	Understand the fundamental and advanced concepts in Botany including Taxonomy, Ecology, Anatomy, Embryology, Genetics, Physiology, Molecular Biology and Evolution.
PSO 2.	Interpret and evaluate plant-environment interactions, including physiological, ecological, and molecular responses to biotic and abiotic factors.
PSO 3.	Design, conduct, and analyze laboratory experiments in diverse areas of Botany using appropriate scientific tools, techniques, and data interpretation methods.
PSO 4.	Demonstrate an understanding of sustainable resource utilization, evaluate the potential for bioprospecting, and develop skills for plant-based innovation and bio-entrepreneurship.

PROGRAMME STRUCTURE
Master of Science in Botany
Effective from Academic Year 2025-26

Bridge Course			
Sr. No.	Course Code	Title of the Course	Credits
1	BOT-1000	Fundamentals of Botany	2
2	BOT-1001	Basics of Biological Chemistry	2

*Students who have qualified the change of discipline test will be offered Bridge Courses

SEMESTER I				
Discipline Specific Core (DSC) Courses (16 credits)				
Sr. No.	Course Code	Title of the Course	Credits	Level
1	BOT-5000	Algae, Bryophytes, Pteridophytes, and Gymnosperms	3	400
2	BOT-5001	Lab in Algae, Bryophytes, Pteridophytes, and Gymnosperms	1	400
3	BOT-5002	Systematics of Angiosperms	3	400
4	BOT-5003	Lab in Systematics of Angiosperms	1	400
5	BOT-5004	Internal Morphology and Developmental Biology of Angiosperms.	3	400
6	BOT-5005	Lab in Internal Morphology and Developmental Biology of Angiosperms	1	400
7	BOT-5006	Plant Physiology	3	400
8	BOT-5007	Lab in Plant Physiology	1	400
Total Credits for DSC Courses in Semester I			16	
Discipline Specific Elective (DSE) Course (4 credits)				
Sr. No.	Course Code	Title of the Course	Credits	Level
1	BOT-5201	Plant Tissue Culture	3	400
2	BOT-5202	Lab in Plant Tissue Culture	1	400
3	BOT-5203	Plant Biochemistry	3	400
4	BOT-5204	Lab in Plant Biochemistry	1	400
Total Credits for DSE Courses in Semester I			4	
Total Credits in Semester I			20	

SEMESTER II				
Discipline Specific Core (DSC) Courses				
Sr. No.	Course Code	Title of the Course	Credits	Level
1	BOT-5008	Microbiology and Plant Pathology	3	500
2	BOT-5009	Lab in Microbiology and Plant Pathology	1	500
3	BOT-5010	Plant Genetics and Breeding	3	500
4	BOT-5011	Lab in Plant Genetics and Breeding	1	500
5	BOT-5012	Plant Molecular Biology	3	500
6	BOT-5013	Lab in Plant Molecular Biology	1	500
7	BOT-5014	Plant Genetic Engineering	3	500
8	BOT-5015	Lab in Plant Genetic Engineering	1	500
Total Credits for DSC Courses in Semester II			16	
Discipline Specific Elective (DSE) Courses (4 credits)				
Sr. No.	Course Code	Title of the Course	Credits	Level
1	BOT-5205	Plant Ecology and Environment	3	400
2	BOT-5206	Lab in Plant Ecology and Environment	1	400
3	BOT-5207	Applied Plant Histochemistry	3	400
4	BOT-5208	Lab in Applied Plant Histochemistry	1	400
Total Credits for DSE Courses in Semester II			4	
Total Credits in Semester II			20	

BRIDGE COURSES

Title of the Course	Fundamentals of Botany
Course Code	BOT-1000
Number of Credits	2
Theory/Practical	Theory
Level	100
Effective from AY	2025-2026
New Course	Yes
Bridge Course/ Value added Course	Bridge Course
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	<ul style="list-style-type: none"> To increase the understanding about the diversity, identification, classification, evolutionary history, relationship of plants with man and other sciences. To understand the fundamentals of different branches in Botany, studying the plants with regards to their morphological features, and biological functioning of plants and various plant processes with emphasis on basic instruments and techniques used in the Botanical studies. 	
Course Outcomes:	Students will be able to:	Mapped to PSO
	CO 1. Understand the basic structure and function of plant cells, tissues, and organs.	PSO2
	CO 2. Identify and classify major plant groups including algae, fungi, bryophytes,	PSO1

	pteridophytes, and gymnosperms.			
	CO 3. Explain fundamental physiological processes such as photosynthesis, respiration, and water transport.		PSO1, PSO2	
	CO 4. Understand the ecological roles and economic significance of various plant groups.		PSO1, PSO2	
Content:		No of hours	Mapped to CO	Cognitive Level
Module 1:	<p>1.1. Introduction to Botany: Introduction to plant kingdom; Scope of Botany; Importance and applications of botany in agriculture, medicine, and environment; Relation of plants to man.</p> <p>1.2. Cell Biology: Structure and function of plant cells; Cell wall, plasma membrane, and organelles; Cell division: Mitosis and meiosis; Cell cycle and its regulation.</p> <p>1.3. Plant Taxonomy and Systematics: Broad classification of plant kingdom: Introduction to seven kingdom classification of life; Major groups of plants: Algae, Fungi, Bryophytes, Pteridophytes, Gymnosperms and Angiosperms; Binomial nomenclature and classification systems (Artificial, Natural, Phylogenetic); major plant families, Herbarium techniques and field collection.</p> <p>1.4. Plant Anatomy: Tissues: Meristematic and permanent tissues; Tissue systems: Dermal, ground, and vascular tissue; Anatomy of root, stem, and leaf (monocot and dicot); Secondary growth in dicot stem and root.</p> <p>1.5. Plant Morphology: Morphology of root, stem, leaf, flower, fruit, and seed; Types of inflorescences; Modifications of roots, stems, and leaves.</p>	15	CO1, CO2	K1, K2
Module 2:	<p>2.1 Plant Ecology: Ecosystem: Components and energy flow; Plant adaptations: Hydrophytes, xerophytes, halophytes; Ecological succession; Biodiversity and conservation.</p> <p>2.2 Plant Reproduction: Asexual and sexual reproduction; Structure of flower: Microsporogenesis and Megasporeogenesis; Pollination and fertilization; Seed</p>	15	CO3, CO4	K1, K2

	<p>development and dispersal.</p> <p>2.3 Plant Physiology: Photosynthesis: Light and dark reactions; Respiration: Aerobic and anaerobic respiration; Transpiration and water absorption; Mineral nutrition and nitrogen metabolism; Plant growth regulators (auxins, gibberellins, cytokinins, ABA, ethylene).</p> <p>2.4 Genetics: Mendel's laws of inheritance; Monohybrid and dihybrid crosses; Chromosomes and gene concept.</p> <p>2.5 Economic Botany: Useful and harmful plants; Medicinal plants, food plants (cereals, pulses), oils, fibers, timber plants.</p>			
Pedagogy:	Lectures/ Use of Multimedia / Assignments/ Demonstrations			
Text Books:	<ol style="list-style-type: none"> 1. Bhojwani, SS, Bhatnagar, SP, Dantu, PK (2015) The embryology of Angiosperms. 6th Edition. Vikas Publishing House Pvt. Ltd., New Delhi. 2. Davis, PH and Heywood, VH (1963) Principles of Angiosperm Taxonomy. Oliver & Boyd, London. 3. Gangulee, SC, Das, KS, Dutta, CD. and Kar, AK (1968) College Botany Vol. I, II and III. Central Education Enterprises. 4. Gifford, EM and Foster, AS (1988) Morphology and Evolution of Vascular Plants, W.H. Freeman & Company, New York. 5. Hopkins, WG and Huner, NP (2009) Introduction to Plant Physiology. 4th edition. John Wiley & Sons, U.S.A. 6. Jain, VK (2017) Fundamentals of Plant Physiology. 19th edition. S. Chand Company Ltd. New Delhi. 7. Lawrence, GHM (1951) Taxonomy of Vascular Plants. MacMillan, New York. Pandey, BP (2014) Plant Anatomy. S. Chand & Company Pvt. Ltd., New Delhi. Sambamurty AVSS (2006) A Textbook of Bryophytes, Pteridophytes, Gymnosperms and Paleobotany. I.K. International publication, New Delhi. 8. Singh, V, Pandey, PC and Jain, DK (2017) Anatomy of Angiosperms, Rastogi Publication, Meerut. 			
References/ Readings:	<ol style="list-style-type: none"> 1. Gurumani, N (2006) Research methodology for biological sciences. MJP Publishers, Chennai. 2. Sharma VK (1991) Techniques in microscopy and cell biology. Tata McGraw-Hill, New Delhi. 3. Singh, G. (2012) Plant Systematics. Theory and Practice. 3rd edition. Oxford & IBH Pvt. Ltd., New Delhi. 			
Web Resources:	<ol style="list-style-type: none"> 1. https://archive.org/details/textbookofgenera029793mbp 2. https://archive.org/details/fundamentalsofbo0000unse_z7a4 			

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| | <ol style="list-style-type: none">3. https://dokumen.pub/fundamentals-of-botany-1-9780070681767-0070681767.html4. https://herba.msu.ru/shipunov/school/biol_154/textbook/intro_botany.pdf5. https://www.researchgate.net/publication/387541607 Fundamentals of Botany |
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Title of the Course	Fundamentals of Biological Chemistry
Course Code	BOT-1001
Number of Credits	2
Theory/Practical	Theory
Level	100
Effective from AY	2025-26
New Course	Yes
Bridge Course/ Value added Course	Bridge course
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	<ul style="list-style-type: none"> To provide foundational knowledge of biomolecules, enzyme function, and basic metabolic pathways. Enable students from diverse backgrounds to understand core concepts of plant biochemistry essential for advanced courses. 	
Course Outcomes:	Students will be able to:	Mapped to PSO
	CO 1. Understand the structure, classification, and biological functions of key biomolecules	PSO1
	CO 2. Explain the role and significance of water and buffers in biological systems.	PSO1
	CO 3. Understand the role of coenzymes and cofactors in enzymatic reactions and energy metabolism	PSO1

	CO 4. Describe the basic principles of metabolic pathways such as glycolysis, TCA cycle, and photosynthesis in biological systems.		PSO1	
Content:		No of hours	Mapped to CO	Cognitive Level
Module 1:	Introduction to Biomolecules 1.1 Introduction to Biochemistry: Biochemistry and its relevance to life sciences. 1.2 Carbohydrates: Classification and types of carbohydrates 1.3 Proteins: Classification of amino acids and proteins 1.4 Lipids: Types of lipids and their biological significance 1.5 Nucleic Acids: Structure and functions of Nucleic acids 1.6 Water and pH: Importance of water, hydrogen bonding, pH, and buffers in biological systems	15	CO1, CO2	K1, K2
Module 2:	Basics of Enzymes, Energy & Metabolism 2.1 Introduction to Enzymes: Importance in biological systems, examples of enzyme catalyzed reaction 2.2 Classification of Enzymes: six major classes 2.3 Enzyme Structure and Function 2.4 Coenzymes and cofactors 2.5 Overview of Metabolism 2.6 Introduction to Glycolysis and TCA Cycle 2.7 Basic concepts of Photosynthesis	15	CO3, CO4	K1, K2
Pedagogy:	Lectures, MOOCs, Interactive Sessions, Group Discussion			
Text Books:	1. Berg, J. M., Tymoczko, J. L., Gatto, G. J., & Stryer, L. (2019). Biochemistry (9th ed.). W. H. Freeman and Company. 2. Jain, J. L., Jain, S., & Jain, N. (2016). Fundamentals of Biochemistry (6th ed.). S. Chand Publishing. 3. Nelson, D. L., & Cox, M. M. (2021). Lehninger Principles of Biochemistry (8th ed.). W. H. Freeman and			

	<p>Company.</p> <p>4. Satyanarayana, U., & Chakrapani, U. (2017). Biochemistry (5th ed.). Elsevier India.</p> <p>5. Voet, D., Voet, J. G., & Pratt, C. W. (2016). Fundamentals of Biochemistry: Life at the Molecular Level (5th ed.). Wiley.</p>
References/ Readings:	<p>1. Koshland, D. E. (2002). The seven pillars of life. Science, 295(5563), 2215–2216. https://doi.org/10.1126/science.1068489</p> <p>2. Petsko, G. A. (2000). Structural basis of enzyme catalysis and specificity: Is there a common mechanism? Biochemistry and Molecular Biology Education, 28(2), 62–63. https://doi.org/10.1002/bmb.2000.494028020148</p> <p>3. Nelson, D. L., & Cox, M. M. (2004). The dawn of biochemistry. Nature Reviews Molecular Cell Biology, 5(5), 383–387. https://doi.org/10.1038/nrm1371</p>
Web Resources:	<p>1. https://www.biochemistry.org/education/</p> <p>2. https://bio.libretexts.org/Bookshelves/Biochemistry</p> <p>3. https://www.ncbi.nlm.nih.gov/books/</p>

SEMESTER I

Discipline Specific Core Courses

Title of the Course	Algae, Bryophytes, Pteridophytes and Gymnosperms
Course Code	BOT-5000
Number of Credits	3
Theory/Practical	Theory
Level	400
Effective from AY	2025-2026
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	<ul style="list-style-type: none">• To study general characteristics, classification, trends in classification, phylogeny and inter-relationships of Algae, Bryophytes, Pteridophytes, Gymnosperms and Angiosperms.• To get a clear idea of the characteristics of the important plant groups and concepts in the evolution taught in this paper.	
Course Outcomes:	Students will be able to:	Mapped to PSO
	CO 1. Describe the morphology, structure, and life cycles of algae, bryophytes, pteridophytes, and gymnosperms.	PSO1

	CO 2. Compare and contrast the evolutionary trends among cryptogams and gymnosperms.		PSO1	
	CO 3. Classify different groups based on anatomical and reproductive features.		PSO1	
	CO 4. Evaluate the ecological and economic roles of non-flowering plants.		PSO1, PSO4	
Content:		No of hours	Mapped to CO	Cognitive Level
Module 1:	Algae: General introduction to algae including Cyanobacteria: Classification of Algae; Recent trends in the classification of Algae; General account of morphology, anatomy, reproduction, life histories, classification, phylogeny and inter-relationship, ecological and economic importance of the following groups: Chlorophyta, Charophyta, Chrysophyta, Cryptophyta, Pyrrophyta, Phaeophyta and Rhodophyta.	12	CO1, CO2, CO3, CO4	K1, K2, K3
Module 2:	Bryophyta: Introduction to Bryophyta: General characteristics, classification; Distribution, morphological, anatomical, reproductive studies and comparative account of sporophytes and gametophytes and interrelationships of the following groups: Hepaticae: Sphaerocarpaceae, Calobryales, Takakiales, Marchantiales, Jungermanniales, Anthocephales: Anthocerotales; Musci: Sphagnales, Andrales, Polytrichales, Buxbaumiales, Funariales including their fossil relatives.	13	CO1, CO2, CO3, CO4	K1, K2, K3
Module 3:	Pteridophyta: General characters and classification of Pteridophytes; Comparative account of Psilophyta, Lycophyta, Equisetophyta and Flicophyta; Aposory and Apogamy, Heterospory, Soral Evolution, Fossil Pteridophytes. Gymnosperms: General characters and Classification of Gymnosperms; Comparative account of Morphology, anatomy, phylogeny and interrelationships of Pro-Gymnospermopsida, Gymnospermopsida, Gnetopsida and Fossil Gymnosperms.	20	CO1, CO2, CO3, CO4	K1, K2, K3
Pedagogy:	Lectures/Assignments/Group Discussion/ Seminars			
Text Books:	1. Afroz Alam (2015) Textbook of Bryophyta I. K. International Publishing House Private Ltd., New Delhi.			

	<ol style="list-style-type: none"> 2. Fritsch, F.E. (1965) The structure and Reproduction of Algae. Cambridge University Press 3. Bold and Harold Charles (1909). Introduction to algae: Structure and reproduction. Englewood Cliffs, N.J. Prentice-Hall. 4. Watson E.V. (1914) The structure and life of Bryophytes. Hutchinson Univ. Press, London. 5. Smith G.M. (1938) Cryptogamic Botany. McGraw-Hill Book Co., New York. 6. Parihar N.S. (2013) An introduction to Embryophyta: Bryophyta. Fifth Edition. Surjeet Publications, New Delhi,
<p>References/ Readings:</p>	<ol style="list-style-type: none"> 1. Agashe, S.N. (1995) Paleobotany, Oxford and IBH Publ. Co. Pvt. Ltd, New Delhi. 2. Arnold, A.C. (2005) An Introduction to Paleobotany, Agrobios (India), Jodhpur. 3. Bhatnagar S. P. and Moitra A. (1996) Gymnosperms. New Age International, New Delhi. 4. Afroz Alam (2015) Text Book of Bryophyta I. K. International Publishing House Private Ltd., New Delhi. 5. Agashe, S.N. (1995) Paleobotany. Oxford and IBH Publ. Co. Pvt. Ltd, New Delhi. 6. Arnold, A.C. (2005) An Introduction to Paleobotany, Agrobios (India), Jodhpur. 7. Bhatnagar S. P. and Moitra A. (1996) Gymnosperms. New Age International, New Delhi. 8. Bold H.C. and Wynne M.J. (1985) Introduction to the algae; Structure and reproduction. Prentice Hall, Englewood cliffs, New Jersey. 9. Chapman V.J. and Chapman D.J. (1975) The algae, 2nd Edition, Mac. Millan Publ. Inc. New York. 10. Chopra, R. N., and Kumar P. K. (1988) Biology of Bryophytes. John Wiley and Sons, New York, NY. 11. Desikachary, T.V. (1959) Cyanophyta. ICAR, New Delhi. 12. Hoek, C. van den, Mann, D.G. and Jahns, H.M. (1995) Algae: An Introduction to Phycology, Cambridge University Press, UK. 13. Johri, R.M., Lata, S. and Tyagi, K. (2012) A Textbook of Bryophyta. Dominant Publishers &. Distributors Pvt., Ltd., New Delhi. 14. Kashyap, Shiv Ram, (1932) Liverworts of the western Himalayas and the Punjab plain (illustrated): Part 2. The Chronica Botanica New Delhi. 15. Kramer, K.U. and Green, P.S. (2013) Pteridophytes and Gymnosperms. Springer Science & Business Media. Springer Berlin Heidelberg.

	<p>16. Parihar, N.S. (1976) Biology and Morphology of the Pteridophytes. Central Book Depot.</p> <p>17. Parihar, N.S. (1980) Bryophytes: An introduction to Embryophyta. Vol. I Bryophyta. Central Book Depot.</p> <p>18. Prem Puri (1981) Bryophytes: Morphology, Growth and Differentiation, Atmaram and Sons, New Delhi.</p> <p>19. Prescott G. W. (1969) The algae: A review. Nelson, London.</p> <p>20. Rashid, A. (1999) An Introduction to Pteridophyta, Vikas Publishing House Pvt. Ltd., New Delhi.</p> <p>21. Ramanujan, C.K.G. (1970) Indian Gymnosperms in time and space. Today & Tomorrow's Printers & Publishers.</p> <p>22. Sharma, O.P. (1990) Textbook of Pteridophyta. Macmillan India Ltd., Delhi.</p> <p>23. Singh, V. P. (2006) Gymnosperms (Naked seed plants): Structure and Development, Sarup and Sons, New Delhi.</p>
Web Resources:	<ol style="list-style-type: none"> 1. https://uou.ac.in/sites/default/files/slm/MSCBOT-502.pdf 2. https://www.scribd.com/document/797014468/Text-Book-of-BRYOPHYTES-PTERIDOPHYTES-GYMNOSPERM-PALEOBOTANY-Complete-E-Book 3. https://ncert.nic.in/textbook/pdf/kebo103.pdf 4. https://www.bdu.ac.in/cde/REVISEDSLM/PG/Botany

Title of the Course	Lab in Algae, Bryophytes, Pteridophytes and Gymnosperms
Course Code	BOT-5001
Number of Credits	1
Theory/Practical	Practical
Level	400
Effective from AY	2025-2026
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	<ul style="list-style-type: none"> ● To introduce and acquaint the students to skills required in the field and laboratory based on theory. ● To understand technical descriptions of plants and construct and use keys for identification, morphological, anatomical and reproductive characteristics of the respective plant groups. ● To have a better understanding in the area of lower plant groups and will be able to carry out research work in this field. 	
Course Outcomes:	Students will be able to:	Mapped to PSO
	CO 1. Identify representative genera of algae, bryophytes, pteridophytes, and gymnosperms using morphological and anatomical features	PSO1, PSO3
	CO 2. Prepare permanent, temporary slides and herbarium to study internal structures and reproductive organs.	PSO1, PSO3

	CO 3. Demonstrate the ability to identify and study representative genera through practical observations.		PSO1, PSO3
	CO 4. Differentiate between various groups based on diagnostic characters.		PSO1, PSO3
Content:		No of hours	Mapped to CO Cognitive Level
Module 1:	1. Study of vegetative and reproductive features of important algal groups, including Cyanobacteria with available representatives; Chlorophyta, Charophyta, Euglenophyta, Pyrrhophyta, Phaeophyta and Rhodophyta.	8	CO1, CO2, CO3, CO4 K1, K2, K3
	2. Study of vegetative and reproductive features of important bryophyte groups, represented by the available representatives: Hepaticae, Anthocerotae, and Musci.	8	CO1, CO2, CO3, CO4 K1, K2, K3
	3. Study of vegetative and reproductive features of important Pteridophytes with the available representatives: Psilotales, Lycopodiales, Selaginellales, Isoeteales, Equisetales, Ophioglossales, Marrattiales, Osmundales, Filicales, Marsileales and Salviniiales.	8	CO1, CO2, CO3, CO4 K1, K2, K3
	4. Study of vegetative and reproductive features of important Gymnosperms and Gnetopsida with the available representatives.	6	CO1, CO2, CO3, CO4 K1, K2, K3
Pedagogy:	Hands-on practicals/field visits/Demonstrations/mini-projects.		
Text Books:	<ol style="list-style-type: none"> Biswas C. and Johri B.M. (1997) Gymnosperms. Narosa Publishers, New Delhi. Bold H.C. and Wynne M.J. (1985) Introduction to algae; Structure and reproduction. Prentice Hall, Englewood cliffs, New Jersey. Desikachary, T.V. (1959) Cyanophyta. ICAR, New Delhi. Parihar, N.S. (1976) Biology and Morphology of the Pteridophytes. Central Book Depot. Prem Puri (1981) Bryophytes: Morphology, Growth and Differentiation, Atmaram and Sons, New Delhi. 		

	6. Rashid, A. (1999) An Introduction to Pteridophyta, Vikas Publishing House Pvt. Ltd. New Delhi.
References/ Readings:	<ol style="list-style-type: none"> 1. Bellinger, E.G., & Sigeo, D.C. (2015) Freshwater algae: identification, enumeration and use as bioindicators. John Wiley & Sons, UK. 2. Parihar, N.S. (1980) Bryophytes: An introduction to Embryophyta Vol I Bryophyta central Book Depot. 3. Prescott G.W. (1969) The algae: A review. Nelson, London. 4. Ramanujan, C.K.G. (1970) Indian Gymnosperms in time and space. Today & Tomorrow's Printers & Publishers. 5. Sporne, K.R. (1986) The morphology of Pteridophytes. Hutchinson University Press. London 6. Smith, G.M. (1995) The fresh water Algae of the United States, Mc-Graw Hill, New York. 7. Vashishta B.R. (1988) Algae. S. Chand & Co., New Delhi. 8. Waston E.V. (1971) Structure and life of Bryophytes. 3rd Edition. Hutchinson University Library, London.
Web Resources:	<ol style="list-style-type: none"> 1. https://www.srcollege.edu.in/temp/lms/Manuals/Practical-I.pdf 2. https://uou.ac.in/sites/default/files/slm/BSCBO-103.pdf 3. https://womengovtcollegevisakha.ac.in/departments

Title of the Course	Systematics of Angiosperms
Course Code	BOT-5002
Number of Credits	3
Theory/Practical	Theory
Level	400
Effective from AY	2025-26
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil
Course Objectives:	<ul style="list-style-type: none"> ● Introduce the foundational principles, goals, and importance of plant taxonomy and systematics, including classical and modern approaches. ● Provide conceptual understanding of analytical, numerical, and molecular tools in systematics. ● Develop competence in understanding phylogenetic relationships and modern classification systems, particularly APG IV. ● Equip students to integrate molecular, ecological, and morphological data for plant identification, conservation, and classification. ● Encourage critical evaluation of recent advances in taxonomy, including AI-based tools, citizen science, and global governance frameworks.
Course Outcomes:	Students will be able to: Mapped to PSO

	CO 1. Understand the principles, goals, and applications of plant taxonomy and systematics in biodiversity conservation and ecosystem research.		PSO 1, PSO 2	
	CO 2. Interpret the structure and functions of Floras, Monographs, and Revisions, and demonstrate the effective use of herbaria and taxonomic literature.		PSO 1	
	CO 3. Apply nomenclatural principles and ICN rules in hypothetical taxonomic scenarios to assess the validity of names and typification.		PSO 1, PSO 3	
	CO 4. Analyze and compare the theoretical foundations and applications of numerical taxonomy, cladistics, and molecular systematics to infer phylogenetic relationships.		PSO 1, PSO 3	
	CO 5. Compare modern phylogenetic classification systems, including APG IV, and interpret evolutionary relationships among major angiosperm clades.		PSO 1, PSO 2	
	CO 6. Evaluate recent advancements in integrative taxonomy and analyze their implications for conservation biology and digital taxonomy.		PSO 2, PSO 4	
Content:		No of hours	Mapped to CO	Cognitive Level
Module 1:	<p>Principles and Foundations of Plant Systematics</p> <p>1.1 Plant Taxonomy Scope and significance of plant taxonomy; taxonomy as a synthetic and dynamic discipline; principles and goals. Applications of taxonomy in biodiversity conservation, ecosystem management, restoration ecology, ethnobotany, and climate resilience. Conservation priorities and frameworks (e.g., IUCN Red List, CBD, IPBES assessments).</p> <p>1.2 Floras, Revisions and Monographs Definition, scope, and structure of Floras, Revisions, and Monographs. Methodologies involved in floristic, revisionary, and monographic studies. Role of regional, national, and global floristic compilations. Importance of classical and modern resources including printed and digitized floras. Contribution of</p>	15	CO1, CO2, CO3	K1, K2, K3, K4

	<p>herbaria, botanical gardens, virtual repositories, and digitization initiatives in taxonomic studies. Standard practices in specimen collection, preservation, and herbarium curation.</p> <p>1.3 Nomenclature: Purpose and principles of botanical nomenclature. Understanding the structure and rules of the International Code of Nomenclature for algae, fungi, and plants (ICN), with emphasis on key concepts: typification, valid and effective publication, principle of priority, author citation. Interpretation and application of current Articles of the Code; understanding nomenclatural decisions and amendments as per the evolving Codes of ICN.</p> <p>1.4 Phytogeography Basic concepts and approaches in phytogeography; static and dynamic plant distributions. Types of distribution: continuous, discontinuous, endemism (neoendemics and paleoendemics). Theories of plant distribution: continental drift, land bridges, and polar oscillation. Floristic regions of the world and India (as per BSI classification). Relevance to plant migration, speciation, and conservation planning.</p>			
Module 2:	<p>Analytical Tools in Taxonomy and Molecular Cladistics</p> <p>2.1 Numerical Taxonomy (Phenetics) Phenetic methods: Collection and coding of morphological data, creation of taxonomic matrices. Cluster analysis, similarity coefficients, Principal Component Analysis (PCA), Discriminant Function Analysis. Use of tools such as PAST, MorphoJ, R, and AI-assisted morphometric platforms. Applications in delimiting cryptic species and resolving infra-specific variability.</p> <p>2.2 Cladistics and Phylogenetic Systematics Historical development and principles of cladistics. Character analysis: polarity, homology, analogy, apomorphy vs plesiomorphy, binary and multistate characters. Concepts of monophyly, paraphyly, polyphyly. Parsimony-based and model-based tree construction (maximum likelihood, Bayesian inference). Use of software: PAUP*, MrBayes, MEGA, RAxML, IQ-TREE. Importance of tree</p>	15	CO4, CO6	K1, K2, K3, K4

	<p>rooting and interpreting support values (bootstrap, posterior probabilities).</p> <p>2.3 Molecular Systematics</p> <p>Molecular markers used in plant taxonomy (chloroplast, nuclear, mitochondrial). DNA barcoding (matK, rbcL, ITS, trnH-psbA). Sequence retrieval and alignment (BLAST, ClustalW, MUSCLE). Concepts of molecular clock and neutral theory. Recent trends in phylogenomics, targeted sequencing, RADseq, and genome skimming. Role of databases: NCBI GenBank, BOLD, Phytozome</p>			
Module 3:	<p>Module III: Modern Classification Systems and Emerging Trends</p> <p>3.1 Phylogeny and Evolution of Angiosperms Evolutionary history and radiation of angiosperms. Fossil evidence and implications for phylogeny. Ancestral traits and adaptive radiations. Interpreting phylogenetic trees in the context of paleobotany, ecology, and molecular data. Applications in trait evolution and biogeographical history.</p> <p>3.2 Modern Classification Systems Fossil angiosperms and their ecology. Critical comparison of traditional (Bentham & Hooker, Engler & Prantl, Cronquist) and phylogenetic systems. Detailed overview of the Recent systems of classification; APG IV system of classification of angiosperms; characteristics and phylogeny of clades: Ordes-Amborellales, Nymphaeales, Austrobaileyales, Chloranthales; Clades (Magnoliids), (Monocots (Commelinids)), Order Ceratophyllales, (eudicots ((Superrosids (Rosids, Fabids, Malvids))) and (Superasterids (asterids (campanulids, lamids))))))</p> <p>3.3 Recent Advances in Systematics Integrative taxonomy—combining classical, molecular, ecological, cytological, and biochemical data. Tools and techniques in next-generation sequencing (NGS), eDNA, metabarcoding, AI-driven taxonomy, automated species recognition, and remote sensing in floristic exploration. Role of citizen science and indigenous knowledge. Legal and ethical dimensions: Nagoya Protocol, access and benefit sharing, digital sequence information (DSI) governance.</p>	15	CO4, CO5, CO6	K2, K4, K5, K6

Pedagogy:	Lectures/Assignments/Seminars/Group Discussions/Case-Based Learning/Mini Projects
Text Books:	<ol style="list-style-type: none"> 1. Arun AK, Ritesh KC, Mayank DD, Shruti K (2024). Plant Molecular Systematics. A Laboratory Manual, Deepika Book Agency, Delhi-India. 2. Singh G (2021) (4th ed.). Plant Systematics: Theory and Practice. Oxford & IBH Publishing Company Pvt. Limited. 3. Singh G (2024) (4th ed.). Plant Systematics: An Integrated Approach. CRC Press, USA.
References/ Readings:	<ol style="list-style-type: none"> 1. APG IV 2016 An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants: APG IV, Botanical Journal of the Linnean Society, Volume 181, Issue 1, 1 May 2016, Pages 1–20, https://doi.org/10.1111/boj.12385 2. Barry G. Hall. (2017) Phylogenetic Trees Made Easy: A How-To Manual (5th ed.). Sinauer Associates, Inc., Sunderland, USA. 3. Besse, P. (2014) Guidelines for the choice of sequences for molecular plant taxonomy. In Molecular Plant Taxonomy (pp. 39-51). Humana Press, Totowa, NJ. 4. Cronquist, A. (1981) An Integrated System of Classification of Flowering Plants. Columbia University Press, New York. 5. Dehgan, Bijan. (2023) Garden Plants Taxonomy: Volume 2: Angiosperms (Eudicots). Springer. 6. Goloboff, P.A. (2022) Refining Phylogenetic Analyses: Phylogenetic Analysis of Morphological Data. Species and Systematics Series, Vol. 2. CRC Press. 7. Joesph Felsenstein (2003) Inferring Phylogenies. Sinauer Associates, Inc. (Now Oxford University Press). 8. Judd, W. S., Campbell, C. S., Kellogg, E. A., Stevens, P. F., & Donoghue, M. J. (2015) Plant Systematics: A Phylogenetic Approach (4th ed.). Sinauer Associates. 9. Hamilton, A. (2013). The Evolution of Phylogenetic Systematics. University of California Press, Berkeley, USA. 10. Michael G. Simpson (2010) Plant Systematics (2nd ed.). Academic Press, Elsevier, Amsterdam. 11. Page, N. (2017) Photographic guide to endemic woody plants of western ghats. Trail Blazer Printers and Publishers, New York. 12. Papini, A., Ahmad, M., Ullah, F., & Zaman, W. (2023) Recent Progress in Plant Taxonomy and Floristic Studies. MDPI Books, Switzerland. 13. Peruzzi, L. (2023) Advances in Plant Taxonomy and Systematics. MDPI, Switzerland.

	<p>https://doi.org/10.3390/biology12040570</p> <ol style="list-style-type: none"> 14. Simpson, M. G. (2019) Plant Systematics (3rd ed.). Academic Press. 15. Sivarajan, V.V. (1991) (2nd ed.). Introduction to the Principles of Plant Taxonomy (Ed. N S K Robson). Oxford & IBH publishing Co. Pvt. Ltd. 16. Stuessy, T. F. (2009) Plant Taxonomy: The Systematic Evaluation of Comparative Data (2nd ed.). Columbia University Press. 17. Takhtajan, A. (Ed.). (2009) Flowering plants. Dordrecht: Springer Netherlands. 18. Turland, N. J., Wiersema, J. H., Barrie, F. R., et al. (2018) International Code of Nomenclature for algae, fungi, and plants (Shenzhen Code) adopted by the Nineteenth International Botanical Congress Shenzhen, China, July 2017. Koeltz Botanical Books. https://doi.org/10.12705/Code.2018 19. Walter S. Judd, Christopher S. Campbell, Elizabeth A. Kellogg, Peter F. Stevens, and Michael J. Donoghue (2015) Plant Systematics: A Phylogenetic Approach (4th ed.). Sinauer Associates, Inc., Publishers, Sunderland, USA.
<p>Web Resources:</p>	<ol style="list-style-type: none"> 1. http://www.efloras.org/ 2. http://www.mobot.org/mobot/research/apweb/ 3. http://www.theplantlist.org/ 4. http://www.worldfloraonline.org/ 5. https://bsi.gov.in/ 6. https://phytozome.jgi.doe.gov/ 7. https://plants.usda.gov/ 8. https://wfoplantlist.org/ 9. https://www.digitalatlasofancientlife.org/ 10. https://www.gbif.org/ 11. https://www.gbif.org/dataset/search 12. https://www.ipni.org/ 13. https://www.kew.org/

Title of the Course	Lab in Systematics of Angiosperms
Course Code	BOT-5003
Number of Credits	1
Theory/Practical	Practical
Level	400
Effective from AY	2025-26
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	<ul style="list-style-type: none"> ● Impart hands-on experience in the identification and classification of angiosperms through floral dissection, use of floras, and herbarium techniques. ● Introduce students to practical aspects of taxonomic research, including preparation of keys, field documentation, and herbarium curation. ● Familiarize students with the use of molecular data and basic bioinformatics tools for phylogenetic analysis. ● Develop the ability to independently identify plant species and interpret their evolutionary relationships using integrative approaches. 	
Course Outcomes:	Students will be able to:	Mapped to PSO
	CO 1. Understand diagnostic morphological characters and perform floral dissection to document technical features of angiosperm specimens.	PSO 1

	CO 2. Demonstrate herbarium specimen preparation and record essential taxonomic data following standard protocols.			PSO 1, PSO 2	
	CO 3. Construct and use dichotomous keys (indented and bracketed) for accurate identification of plant taxa.			PSO 1, PSO 3	
	CO 4. Identify and classify plant species from major angiosperm families using field and floral characteristics.			PSO 1, PSO 2	
	CO 5. Perform basic phylogenetic analysis using molecular data and interpret resulting evolutionary relationships			PSO 2, PSO 3	
	CO 6. Execute mini-floristic surveys and prepare structured reports integrating morphological and ecological observations.			PSO 1, PSO 2, PSO3, PSO 4	
Content:			No of hours	Mapped to CO	Cognitive Level
	1. Writing technical descriptions of flowering plant species based on field observations and dissection, using appropriate botanical terminology, floral formulae, and diagrams		2	CO1	K1, K2, K3
	2. Demonstration of herbarium preparation (pressing, drying, mounting, labelling)		2	CO2	K3, K6
	3. Construction and practice of dichotomous/ indented keys		2	CO3	K3, K4
	4. Identification of local species using Floras, Manuals, dichotomous keys, and field excursions		2	CO3, CO4	K3, K4
	5. Study of diagnostic floral characters of 28 angiosperm families.		16	CO1, CO4	K2, K3
	6. Correlating morphological traits with APG IV clades using examples		2	CO4,	K3, K4,

			CO5	K5
	7. Retrieval of molecular gene sequences from NCBI and Construction of Phylogenetic tree using MEGA/online tools	2	CO5	K2, K3, K5
	8. Mini floristic field project from Goa University campus and submission of report	4	CO6	K3, K6
<i>Only 30 hours for any of the above practicals will be conducted depending on availability of plant material.</i>				
Pedagogy:	Hands-on Practical, Field visits, Group Discussions, Assignments and Mini projects			
Text Books:	<ol style="list-style-type: none"> 1. Arun AK, Ritesh KC, Mayank DD, Shruti K (2024). Plant Molecular Systematics. A Laboratory Manual, Deepika Book Agency, Delhi-India. 2. Singh G (2021) (4th ed.). Plant Systematics: Theory and Practice. Oxford & IBH Publishing Company Pvt. Limited. 3. Singh G (2024) (4th ed.). Plant Systematics: An Integrated Approach. CRC Press, USA. 			
References/ Readings:	<ol style="list-style-type: none"> 1. APG IV 2016 An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants: APG IV, Botanical Journal of the Linnean Society, Volume 181, Issue 1, 1 May 2016, Pages 1–20, https://doi.org/10.1111/boj.12385 2. Barry G. Hall. (2017) Phylogenetic Trees Made Easy: A How-To Manual (5th ed.). Sinauer Associates, Inc., Sunderland, USA. 3. Besse, P. (2014) Guidelines for the choice of sequences for molecular plant taxonomy. In Molecular Plant Taxonomy (pp. 39-51). Humana Press, Totowa, NJ. 4. Cronquist, A. (1981) An Integrated System of Classification of Flowering Plants. Columbia University Press, New York. 5. Dehgan, Bijan. (2023) Garden Plants Taxonomy: Volume 2: Angiosperms (Eudicots). Springer. 6. Goloboff, P.A. (2022) Refining Phylogenetic Analyses: Phylogenetic Analysis of Morphological Data. Species and Systematics Series, Vol. 2. CRC Press. 7. Joesph Felsenstein (2003) Inferring Phylogenies. Sinauer Associates, Inc. (Now Oxford University Press). 8. Judd, W. S., Campbell, C. S., Kellogg, E. A., Stevens, P. F., & Donoghue, M. J. (2015) Plant Systematics: A 			

	<p>Phylogenetic Approach (4th ed.). Sinauer Associates.</p> <p>9. Hamilton, A. (2013). The Evolution of Phylogenetic Systematics. University of California Press, Berkeley, USA.</p> <p>10. Michael G. Simpson (2010) Plant Systematics (2nd ed.). Academic Press, Elsevier, Amsterdam.</p> <p>11. Page, N. (2017) Photographic guide to endemic woody plants of western ghats. Trail Blazer Printers and Publishers, New York.</p> <p>12. Papini, A., Ahmad, M., Ullah, F., & Zaman, W. (2023) Recent Progress in Plant Taxonomy and Floristic Studies. MDPI Books, Switzerland.</p> <p>13. Peruzzi, L. (2023) Advances in Plant Taxonomy and Systematics. MDPI, Switzerland. https://doi.org/10.3390/biology12040570</p> <p>14. Simpson, M. G. (2019) Plant Systematics (3rd ed.). Academic Press.</p> <p>15. Sivarajan, V.V. (1991) (2nd ed.). Introduction to the Principles of Plant Taxonomy (Ed. N S K Robson). Oxford & IBH publishing Co. Pvt. Ltd.</p> <p>16. Stuessy, T. F. (2009) Plant Taxonomy: The Systematic Evaluation of Comparative Data (2nd ed.). Columbia University Press.</p> <p>17. Takhtajan, A. (Ed.). (2009) Flowering plants. Dordrecht: Springer Netherlands.</p> <p>18. Turland, N. J., Wiersema, J. H., Barrie, F. R., et al. (2018) International Code of Nomenclature for algae, fungi, and plants (Shenzhen Code) adopted by the Nineteenth International Botanical Congress Shenzhen, China, July 2017. Koeltz Botanical Books. https://doi.org/10.12705/Code.2018</p> <p>19. Walter S. Judd, Christopher S. Campbell, Elizabeth A. Kellogg, Peter F. Stevens, and Michael J. Donoghue (2015) Plant Systematics: A Phylogenetic Approach (4th ed.). Sinauer Associates, Inc., Publishers, Sunderland, USA.</p>
<p>Web Resources:</p>	<ol style="list-style-type: none"> 1. http://www.efloras.org/ 2. http://www.efloras.org/ 3. http://www.mobot.org/mobot/research/apweb/ 4. http://www.theplantlist.org/ 5. http://www.worldfloraonline.org/ 6. https://bsi.gov.in/ 7. https://phytozome.jgi.doe.gov/

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| | <ol style="list-style-type: none">8. https://plants.usda.gov/9. https://wfoplantlist.org/10. https://www.digitalatlasofancientlife.org/11. https://www.gbif.org/12. https://www.gbif.org/dataset/search13. https://www.ipni.org/14. https://www.kew.org/ |
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Title of the Course	Internal Morphology and Developmental Biology of Angiosperms
Course Code	BOT-5004
Number of Credits	3
Theory/Practical	Theory
Level	400
Effective from AY	2025-26
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	<ul style="list-style-type: none"> • To acquaint the knowledge of structural and developmental organization of angiosperm tissues and organs, focusing on meristematic activity, tissue differentiation, and organ ontogeny. • To understand the processes of microsporogenesis, megasporogenesis, fertilization, embryogenesis, and associated genetic and molecular controls in plant reproduction. • To explore the anatomical diversity of vegetative and reproductive structures, including specialized structures like trichomes, stomata, xylem, and phloem, and their evolutionary adaptations. • To familiarize students with the principles and applications of palynology - including aerobiology, mellittopalynology, paleopalynology, and their relevance to taxonomy, ecology, and crop improvement. • To connect histological and embryological knowledge with applied research areas such as pollen biotechnology, wood anatomy, and transgenic systems for crop development. 	
Course Outcomes:	Students will be able to:	Mapped to PSO

	CO 1. Describe the internal anatomical and embryological structures and explain their functions in flowering plants.		PSO1, PSO2	
	CO 2. Apply anatomical and embryological concepts to interpret developmental stages and assess their importance in applied plant biology.		PSO1, PSO2, PSO3, PSO4	
	CO 3. Analyze structural features such as wood anatomy, embryological tissues, and pollen morphology in higher plants.		PSO1, PSO2, PSO3	
	CO 4. Analyze and apply knowledge of plant anatomy and physiology to interpret developmental and functional processes in angiosperms.		PSO1, PSO2, PSO3, PSO4	
	CO 5. Evaluate applications of pollen biology, biotechnology, and related techniques in plant breeding and reproductive studies.		PSO1, PSO2, PSO3, PSO4	
	CO 6. Develop skills to systematically assess and apply modern techniques in plant anatomy and embryology for research and innovation		PSO3, PSO4	
Content:		No of hours	Mapped to CO	Cognitive Level
Module 1:	<p>Plant Anatomy</p> <p>1.1 Meristems: Shoot and root apical and intercalary meristems; their ultra-structure and histochemistry; cytological and molecular analysis of the shoot apical meristem; autonomy of the meristem and vascular tissue differentiation in the shoot apex.</p> <p>1.2 Vascular cambium vs cork cambium, factors controlling their activity; lenticels; abscission; wound healing.</p> <p>1.3 Ontogeny, phylogeny, evolution, ultra-structure and function of primary and secondary xylem; wood anatomy; bio-deterioration of wood and its prevention.</p> <p>1.4 Ontogeny, phylogeny, evolution, ultra-structure and function of primary and secondary phloem.</p> <p>1.5 Structural variability in leaves including leaf structures of C₃ and C₄ sub-types,</p>	20	CO1, CO2, CO3, CO4, CO5, CO6	K1, K2, K3, K4, K5, K6

	<p>CAM plants; leaf histogenesis; leaf meristems; evolution of leaf forms, heteroblasty. Origin, development and ultra-structure of trichomes and stomata.</p> <p>1.6 Nodal anatomy: Nodal types, phylogenetic and evolutionary considerations.</p> <p>1.7 Anatomy of monocotyledonous and dicotyledonous seeds and fruits - their ontogeny, structure and functions</p>			
Module 2:	<p>Embryology</p> <p>2.1. Microsporogenesis and formation of the male gametophyte: Anther differentiation, pollen development and maturation, gene expression during pollen development, male sterility and pollen abortion, male gametogenesis.</p> <p>2.2. Megasporogenesis and formation of embryo sac: Ovule differentiation and development, megasporogenesis, organization of embryo sac, types of embryo sac, gene function during megagametogenesis.</p> <p>2.3. Pollen pistil interaction and fertilization: Pollen-stigma interaction and pollen tube guidance, pollen recognition by stigma, self-incompatibility, structural, biochemical and molecular aspects of gametophytic and sporophytic self-incompatibility. Double fertilization, <i>in vitro</i> fertilization.</p> <p>2.4. Endosperm and embryogenesis: Endosperm, embryo, nutrition and growth of embryo. Gene action during embryogenesis, storage compounds in endosperm and embryo, storage protein gene expression in transgenic systems; apomixis and polyembryony; applied aspects of embryology.</p>	15	CO1, CO2, CO3, CO4, CO5	K1, K2, K3, K4, K5
Module 3:	<p>Palynology</p> <p>3.1. Pollen Biology: Pollen morphological characters, Pollen wall features, pollen development and evolution of pollen types, palynology and taxonomy.</p> <p>3.2. Aeropalynology: Methods of aerospora survey and analysis; pollen allergy and pollen calendars.</p> <p>3.3. Mellittopalynology: Honey bee and pollen loads; role of apiaries in crop production.</p> <p>3.4. Palaeopalynology: Study of fossil pollens and spores and their significance in paleobotany and coal and oil explorations.</p>	10	CO3, CO4, CO5	K1, K2, K3, K4, K5

	3.5. Pollen biotechnology for crop production and improvement.			
Pedagogy:	Lectures/Assignments/Seminars/Group Discussion			
Text Books:	<ol style="list-style-type: none"> 1. Bhojwani S. S., Bhatnagar S. P. and P.K. Dantu (2015). The Embryology of Angiosperms, (6th Edition), Vikas Publishing House Pvt. Ltd., New Delhi. 2. Esau K. (1985). Plant Anatomy, 2nd Edition, Wiley Eastern Limited, New Delhi. 3. Fahn. A. (1990). Plant Anatomy, 4th Edition, Pergamon press, New York, Oxford. 4. Kashinath Bhattacharya, M. R. Majumdar and S. G. Bhattacharya. (2023). A text Book of Palynology, New Central Book Agency (P) Ltd., Kolkata, India. 			
References/ Readings:	<ol style="list-style-type: none"> 1. Batygina T.B. (2009). Embryology of Flowering Plants Terminology and Concepts, Volume 3, Reproductive Systems, Science Publishers, USA. 2. Bhatnagar, S.P., P.K. Dantu and S.S Bhojwani. (2018). The Embryology of Angiosperms, 6th Edition, Vikas Publishers House, New Delhi. 3. Hesse M. and Ehrendorfer F. (1990). Morphology, Development and Systematic Relevance of Pollen and Spores, Springer- Verlag, New York. 4. Johri B.M. (1984). Comparative Embryology of Angiosperms, Ind. Nat. Sci. Acad., New Delhi. 5. Lyndon R.F. (1990). Plant Development, the Cellular Basis. Cambridge University Press, UK. 6. Maheshwari P. (1985). An Introduction to Embryology of Angiosperms, Tata McGraw Hill, New Delhi. 7. Metcalf C. R. and Chalk L. (1950). Anatomy of Dicots Vol. I & II, London Press, Oxford. 8. Nair P.K.K. (1985). Essentials of Palynology, Asha Publishing House, New York. 9. Raghavan V. (2000). Developmental Biology of Flowering Plants, Springer-Verlag, New York. 10. Richard Crang, Robert Wise, and Sheila Lyons-Sobaski. (2018). Plant Anatomy: A Concept-Based Approach to the Structure of Seed Plants, Springer. 11. Romberger J. A., Hejnowicz Z. and Hill J. F. (1993). Plant Structure: Function and Development, Springer-Verlag. 12. Shivanna, K. R. and Sawhney V. K. (1997). Pollen Biotechnology for Crop Production and Improvement, Cambridge University press. U.K. 			

Title of the Course	Lab in Internal Morphology and Developmental Biology of Angiosperms
Course Code	BOT-5005
Number of Credits	1
Theory/Practical	Practical
Level	400
Effective from AY	2025-26
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	<ul style="list-style-type: none"> ● To understand the anatomical and reproductive structures of flowering plants through microscopic examination of vegetative and reproductive parts. ● To develop technical skills in sectioning, staining, maceration, and microscopy for the study of plant anatomy, embryology, and palynology. ● To apply analytical techniques to identify developmental stages, structural adaptations, and pollen characteristics for classification and ecological interpretation. 	
Course Outcomes:	Students will be able to:	Mapped to PSO
	CO 1. Describe the internal anatomical differences between monocot and dicot roots, stems, leaves, and seeds.	PSO 1, PSO 2
	CO 2. Apply sectioning, staining, and maceration techniques to examine vascular and dermal tissues in plants.	PSO 1, PSO 3

	CO 3. Analyze specialized anatomical features (e.g., stomata, trichomes, lenticels, phytoliths) for classification and adaptation studies.		PSO 1, PSO 2	
	CO 4. Interpret embryological development stages (e.g., microsporogenesis, megasporogenesis, embryo formation).		PSO 1, PSO 2	
	CO 5. Evaluate pollen ornamentation using acetolysis and assess floral sources in honey through palynological techniques.		PSO 2, PSO 4	
	CO 6. Construct permanent slides and document anatomical and reproductive structures using microscopy.		PSO 3, PSO 4	
Content:		No of hours	Mapped to CO	Cognitive Level
	Module 1:			
	1. Comparative anatomy of monocotyledon and dicotyledon root, stem and leaf.	2		
	2. Anatomical basis of identification C3 & C4 photosynthetic sub-types in grasses.	2		
	3. Phytoliths of grasses and their potential use in identification.	2	CO1, CO2, CO3, CO4, CO5, CO6	K1, K2, K3, K4, K5, K6
	4. Anatomy of lenticels and periderm in plants.	2		
	5. Anatomy of monocotyledonous and dicotyledonous seeds.	2		
	6. Study of different types of stomata and trichomes.	2		
	7. Maceration of wood to study xylem components.	4		
	8. Study of microsporangium and microsporogenesis.	2		

	9. Study of megasporangium and embryo sac development.	2		
	10. Study of types of endosperm and its modifications.	2		
	11. Study of development of embryo in dicot and monocot seeds.	2		
	12. Study of different ornamentation patterns in pollen grains by acetolysis method.	4		
	13. Analysis of honey samples to identify uni-floral or multi-floral honey.	4		
	14. Study the different components of phloem.	2		
	15. Quantification of stomatal index and stomatal density from leaf peels.	2		
	Only 30 hours for any of the above practicals will be conducted depending on availability of plant materials.			
Pedagogy:	Hands on Practical/permanent slides			
References/ Readings:	<ol style="list-style-type: none"> 1. Batygina T.B. (2009). Embryology of Flowering Plants Terminology and Concepts, Volume 3, Reproductive Systems, Science Publishers, USA. 2. Bhatnagar, S.P., P.K. Dantu and S.S Bhojwani. (2018). The Embryology of Angiosperms, 6th Edition, Vikas Publishers House, New Delhi. 3. Bhojwani S. S. and Bhatnagar S. P. (1992). The Embryology of Angiosperms, Vikas Publishing House Pvt. Ltd., New Delhi. 4. Esau K. (1985). Plant anatomy, 2nd Edition, Wiley Eastern Limited, New Delhi. 5. Fahn. A. (1990). Plant Anatomy, 4th Edition, Pergamon press, New York, Oxford. 6. Hesse M. and Ehrendorfer F. (1990). Morphology, Development and Systematic Relevance of Pollen and Spores, Springer- Verlag, New York. 7. Johri B.M. (1984). Comparative Embryology of Angiosperms, Ind. Nat. Sci. Acad., New Delhi. 8. Kashinath Bhattacharya, M. R. Majumdar and S. G. Bhattacharya. (2006). A text Book of 			

Palynology, New Central Book Agency (P) Ltd., Kolkata, India.

9. **Lyndon R.F.** (1990). Plant Development, the Cellular Basis. Cambridge University Press, UK.
10. **Maheshwari P.** (1985). An Introduction to Embryology of Angiosperms, Tata McGraw Hill, New Delhi.
11. **Metcalf C. R. and Chalk L.** (1950). Anatomy of Dicots Vol. I & II, London Press, Oxford.
12. **Nair P.K.K.** (1985). Essentials of Palynology, Asha Publishing House, New York.
13. **Raghavan V.** (2000). Developmental Biology of Flowering Plants, Springer-Verlag, New York.
14. **Richard Crang, Robert Wise, and Sheila Lyons-Sobaski.** (2018). Plant Anatomy: A Concept-Based Approach to the Structure of Seed Plants, Springer.
15. **Romberger J. A., Hejnowicz Z. and Hill J. F.** (1993). Plant Structure: Function and Development, Springer-Verlag.
16. **Shivanna, K. R. and Rangaswamy N. S.** (1992). Pollen Biology-A Laboratory Manual, Narosa Publishing House, New Delhi.
17. **Shivanna, K. R. and Sawhney V. K.** (1997). Pollen Biotechnology for Crop Production and Improvement, Cambridge University press. U.K.

Title of the Course	Plant Physiology
Course Code	BOT-5006
Number of Credits	3
Theory/Practical	Theory
Level	400
Effective from AY	2025-2026
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	<ul style="list-style-type: none"> ● To provide knowledge of plant physiological processes, such as photosynthesis, respiration, and water relations, with an emphasis on the mechanisms of abiotic stresses and their impact on crop productivity. ● To understand the mineral nutrition, plant growth and development due to light and phytohormones, with an emphasis on cellular and molecular mechanisms of signal transduction and physiological responses. ● To foster critical thinking and application of concepts to agriculture and environmental sustainability. 	
Course Outcomes:	Students will be able to:	Mapped to PSO
	CO 1. Describe the fundamental physiological processes such as photosynthesis, respiration, transpiration, nitrogen metabolism and mineral uptake in plants.	PSO1, PSO2
	CO 2. Explain the role of plant hormones in regulating growth and development.	PSO1, PSO2

	CO 3. Analyze the impact of abiotic stress on plant physiological functions.		PSO2, PSO2	
	CO 4. Apply physiological principles to assess plant responses under different environmental conditions.		PSO1, PSO2	
Content:		No of hours	Mapped to CO	Cognitive Level
Module 1:	<p>1.1 Plant water relations: Unique physicochemical properties of water; Diffusion, bulk movement of water and substances across the membrane, structure and composition of plasma membrane, Absorption and short-distance transport, pressure-driven bulk flow and long-distance transport. Osmotic potential, water potential gradient; Water absorption by roots via apoplastic, symplastic and transmembrane pathways; Active and passive transport and electrochemical potential gradients; Channels, Role of aquaporins, Water movement through xylem; Mechanism and theories of transport; Stomatal regulation of transpiration, anti-transpirants.</p> <p>1.2 Mineral nutrition: Inorganic nutrition, macro and micro nutrients, deficiency symptoms, hydroponic studies; mineral absorption, translocation and assimilation; Nernst equation and Donnan's equilibrium.</p> <p>1.3 Nitrogen metabolism: Nitrogen cycle, organic nitrogen, nitrogen fixation in legumes, nitrate and ammonia assimilation; Sulfur metabolism and amino acid synthesis; Interrelationship between photosynthesis, respiration and nitrogen metabolism.</p>	15	CO1, CO4	K1, K2, K3
Module 2:	<p>2.1 Photosynthesis: Importance of photosynthesis, Physiological and environmental considerations of photosynthesis.</p> <p>2.2 Light reaction: Radiant energy, light absorption and energy conversion, photosynthetic apparatus, pigments and their biosynthesis; light harvesting complex; characteristics of PSI and PSII photosystems, photosynthetic electron transport, water oxidation and its mechanism, photophosphorylation, ATP synthesis in chloroplast; pseudocyclic electron transport (Mehler's reaction),</p>	15	CO1, CO3, CO4	K1, K2, K3

	<p>Artificial photosynthesis. Climate change & food and fuel security.</p> <p>2.3 Dark reaction: Carbon dioxide fixation in C3, C4 and CAM plants, regulation of Photosynthetic carbon reduction cycle; photorespiration and its regulation, Environmental factors affecting photosynthesis.</p> <p>2.4 Photosynthetic Assimilation: Distribution of photoassimilates: export; Starch and sucrose synthesis; Allocation and partitioning: Phloem loading and unloading; Concept of osmotically generated pressure flow; Importance of plasmodesmata in symplastic transport.</p> <p>2.5 Aerobic and anaerobic respiration: Glycolytic reactions, TCA cycle, Electron transfer system and ATP synthesis in mitochondria; Cyanide independent respiration; cytochrome system; carbohydrate and lipid metabolism; high energy compounds and factors affecting respiration; Chemo-osmotic hypothesis; Interaction between mitochondrial and other cellular components.</p>			
Module 3	<p>3.1 Phytohormones: Auxin; Cytokinin; Gibberellins; Ethylene; ABA. Polyamines; Brassinosteroids, Jasmonate, distribution, physiological role and mechanism of action; Hormonal balance concept.</p> <p>3.2 Photoreceptors: Phytochromes and their properties, light control, regulatory mechanism; role of phytochrome in phototropism; physiology of flowering and fruiting; Cryptochromes.</p> <p>3.3 Reactive oxygen species: ROS generation, its oxidative effect on biomolecules (protein, lipids and DNA); enzymatic and non- enzymatic protective processes, antioxidants.</p> <p>3.4 Stress Physiology: Abiotic stresses (drought, salt, temperature and metal), morphological and cellular adaptation; molecular mechanism of stress tolerance and protection.</p> <p>3.5 Seed dormancy and germination, senescence, programmed cell death; circadian rhythms in plants (with emphasis on exogenous factors and its mechanism).</p>	15	CO1, CO2, CO3, CO4	K1, K2, K3
Pedagogy:	Lectures/ Group discussion/Assignments/Seminars.			

<p>Text Books:</p>	<ol style="list-style-type: none"> 1. Devlin R.M. and Withan F.H. (1983) Plant Physiology. CBS Publishers & Distributors, New Delhi. 2. Hopkins W, Norman P. Hüner A (2008) Introduction to Plant Physiology. 4th Edition, John Wiley & Sons Inc, USA. 3. Salisbury F.B. and Ross C.W. (1991) Plant Physiology. (4th Ed), Wadsworth Publishing Company, Beverly. 4. Taiz L. and Zeiger E. (2006) Plant Physiology. 4th Edition, The Benjamin Cummings Publishing Corporation Inc. 5. Taiz, L., Zeiger, E., Moller I.M., and Murphy, A. (2018) Plant Physiology and development. 6th Edition, Sinaeur Associates, Oxford University Press.
<p>References/ Readings:</p>	<ol style="list-style-type: none"> 1. Blankenship R.E. (2008) Molecular Mechanism of photosynthesis. Blackwell Science, Oxford. 2. Buchanan B.B., Gruissen W. and Jones R.L. (2015) Biochemistry and Molecular Biology of Plants, 2nd Edition, ASPP. 3. Dennis D.T., Turnip D.H., Lefebvre, D.D. and Layzell D.B. (1997) Plant Metabolism. Longman, Singapore. 4. Douce R. (2002) Mitochondria in higher plants: Structure, function and Biogenesis. Academic Press. 5. Edwards G.E. and Walker D. (1992) C3-C4 mechanisms and cellular and environmental regulation of photosynthesis. Univ. California Press. 6. Friedman M.H. (2008) Principles and models of biological transport. Springer-Verlag. 7. Karban R. and Baldwin I. T. (2007) Induced response to herbivory. Uni. Chicago press. Galston A. Life processes of Plants. Sci. Am. Library, New York. 8. Luttige U and Higinbotham N. (1979) Transport in plants. Springer-Verlag, Germany. 9. Mengel K. and Kirkby E.A. (1987) Principles of plant nutrition. Worblaufen-Bern, Switzerland. 10. Moore T.D. (1974) Plant Growth regulators. Kluwer, Dordrecht. The Netherland. 11. Mussel H. and Staples R.C. (1979) Stress physiology in crop plants. Wiley New York. 12. Nobel Park S. (2009) Physicochemical and environmental Plant Physiology. Elsevier Science Publishing Co Inc. 13. Pollock C.J., Farrar J.F. and Gordon, A.J. (1992) Carbon partitioning within and between organisms. BIOS Scientific, Oxford. 14. Senger H. (2012) Blue light effects in biological systems. Springer, Berlin. 15. Smith H. (1980) Phytochrome and photomorphogenesis: An introduction to the photocontrol of plant

	<p>development. McGraw Hill London.</p> <p>16. Thomson Tesar M.B. (2015) Physiological basis of crop growth and development, Panima.</p> <p>17. Wills R. (2016) Post-harvest: An introduction to the physiology and handling of fruit.</p>
Web Resources:	<ol style="list-style-type: none"> 1. https://exa.unne.edu.ar/biologia/fisiologia.vegetal/PlantPhysiologyTaiz2002.pdf 2. https://www.caluniv.ac.in/cbcs-ug/ug-files/UG-Botany.pdf 3. https://www.esalq.usp.br/lepse/imgs/conteudo/Plant-Physiology-by-Vince-Ordog.pdf 4. https://exa.unne.edu.ar/biologia/fisiologia.vegetal/PlantPhysiologyTaiz2002.pdf 5. https://uou.ac.in/sites/default/files/slm/MSCBOT-601.pdf 6. https://www.researchgate.net/publication/382067449_Plant_Physiology_BOOK

Title of the Course	Lab in Plant Physiology
Course Code	BOT-5007
Number of Credits	1
Theory/Practical	Practical
Level	400
Effective from AY	2025-2026
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	<ul style="list-style-type: none"> ● To provide hands-on experience in techniques for studying key physiological processes in plants such as photosynthesis, respiration, transport, growth, development, growth hormones, and the stress physiological aspects of crop yield. ● To enable students to observe, measure, and analyze functions like photosynthesis, respiration, and transpiration. ● To foster practical skills in data collection, interpretation, and scientific reporting. ● To encourage the application of theoretical knowledge to experimental problem-solving in plant sciences. 	
Course Outcomes:	Students will be able to:	Mapped to PSO
	CO 1. Demonstrate practical skills in handling laboratory equipment and conducting experiments related to plant water relations, photosynthesis, and respiration.	PSO1, PSO2, PSO3

	CO 2. Measure and record physiological parameters such as chlorophyll and protein content using standard techniques.		PSO1, PSO3	
	CO 3. Analyze experimental data to interpret plant physiological responses under controlled conditions.		PSO1, PSO2, PSO3	
	CO 4. Design simple experiments to study physiological processes and interpret results to solve practical problems in agriculture.		PSO1, PSO2, PSO3	
Content:		No of hours	Mapped to CO	Cognitive Level
Module I:	1. Verification of the law of diffusion and osmosis.	2	CO1, CO3, CO4	K1, K2, K3
	2. Determination of water potential, osmotic potential and RWC in plant tissue.	2	CO1, CO3, CO4	K1, K2, K3
	3. Analysis of plant tissue for: Water, organic and inorganic content; Determination of a few macronutrients using Flame photometer.	6	CO1, CO3	K1, K2, K3
	4. Extraction and quantitative estimation of protein using Bradford reagent.	2	CO1, CO2, CO3	K1, K2, K3
	5. Determination of ascorbic acid content of tissue.	2	CO1, CO3	K1, K2, K3
	6. Isolation of chloroplast using spinach leaves.	2	CO1, CO2, CO3	K1, K2
	7. Separation of protein by PAGE.	6	CO1, CO2, CO3	K1, K2, K3
	8. Pigments extraction, separation, identification and quantification.	4	CO1, CO2, CO3	K1, K2, K3

	9. Photo-oxidation of plant pigments.	4	CO1, CO2, CO3	K1, K2, K3
	10. Determination of oxidative damage in tissue using TBARS method.	4	CO1, CO3	K1, K2, K3
	11. Effect of plant hormones on seedling growth.	4	CO1, CO3	K1, K2, K3
	12. Non-invasive measurements of photosynthesis using chlorophyll fluorometer.	2	CO1, CO2, CO3	K1, K2, K3
	13. Assay of nitrate/nitrite reductase activity in cyanobacteria.	2	CO1, CO3	K1, K2, K3
	14. Estimation of Proline under stress conditions.	2	CO1, CO3	K1, K2, K3
Pedagogy:	Hands-on Practicals/ Demonstrations.			
Text Books:	<ol style="list-style-type: none"> 1. Bhainagar, R. (1987) Manual of Practical Biochemistry. Delhi IBT Publishing, New Delhi. 2. Boyer, R. (2000) Modern Experimental Biochemistry. Delhi Pearson Education, New Delhi. 3. Harborne, J.B. (2007) Phytochemical Methods. Chapman and Hall, London. 4. Jayaraman, J. (2011) Laboratory Manual in Biochemistry. New Age International Private Limited. New Delhi. 5. Mu, P. and Plummer D.T. (2001) An introduction to Practical Biochemistry. Tata McGraw Hill Publishing Company Limited. New Delhi. 			
References/ Readings:	<ol style="list-style-type: none"> 1. Cooper, T.G. (2011) The Tools of Biochemistry. Wiley India Pvt. Ltd., New Delhi. 2. Devi, P. (2005) Principles and Methods of Plant Molecular Biology, Biochemistry and Genetics. Jodhpur Agrobios, Jodhpur. 3. Harisha, S. (2006) Biotechnology Procedures and Experiments Handbook. Firewall Media, New Delhi. 			

Web Resources:

1. https://coabhatapara.ac.in/downloads/PRACTICAL MANUAL ON PRINCIPLES OF PLANT PHYSIOLOGY_PP-501.pdf
2. https://www.researchgate.net/publication/378906601_PG_Practical_Manual_Experimental_Plant_Physiology_and_Biochemistry_Manual
3. <https://archive.org/details/b21963381>
4. https://www.researchgate.net/publication/369196458_Plant_Physiology-Practical_Manual-BOT-232

Discipline Specific Elective Courses

Title of the Course	Plant Tissue Culture
Course Code	BOT-5201
Number of Credits	3
Theory/Practical	Theory
Level	400
Effective from AY	2025-26
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	To impart recent knowledge in the field of plant biotechnology that is beneficial to the economy and industry.	
Course Outcomes:	Students will be able to:	Mapped to PSO
	CO 1. Understand and apply plant and cell culture techniques for the production, mass cultivation, and enhancement of secondary metabolites and micropropagation in plant biotechnology.	PSO 1

	CO 2. Analyze somaclonal variation, including its causes, applications, and limitations, for crop improvement and genetic stability.		PSO 2, PSO3	
	CO 3. Understand and apply cryopreservation and haploid plant production techniques for germplasm conservation and crop improvement.		PSO 1	
	CO 4. Evaluate the prospects, applications, and limitations of cryobanking and haploid technologies in agricultural and forest biotechnology.		PSO 2 and PSO 3	
	CO 5. Develop skills in protoplast isolation, fusion, regeneration, and somatic hybridization for plant improvement and genetic modification.		PSO 3 and PSO 4	
	CO 6. Evaluate the applications, limitations, and biotechnological benefits of somatic hybridization, gene transfer, and biotechnology in agriculture, forestry, and human welfare.		PSO 3 and PSO 4	
Content:		No of hours	Mapped to CO	Cognitive Level
Module 1:	Plant Tissue Culture: Totipotency; A brief history of plant tissue culture; Laboratory Organisation; Constituents of media, Preparation of media, Selection of a suitable medium. Applications of Plant Tissue cultures. Cell Cultures: Isolation of single cells, Bergmann's Plating Technique, Suspension cultures, types of suspension cultures, Synchronization of suspension cultures, Measurement of growth of cultures, Measurement of viability of cultured cells.	10	CO1	K1, K2, K3
Module 2:	Secondary Metabolites in Plant Culture: Applications of secondary metabolites, Production of secondary metabolites, Selection of cell lines for high yield of secondary metabolites, Mass cultivation of plant cells, medium composition and effect of nutrients, Elicitor-induced production of secondary metabolites.	12	CO1, CO2	K1, K2, K3

	<p>Micropropagation: Techniques of micropropagation, Multiplication by axillary buds, apical shoots and adventitious shoots, Factors affecting micropropagation, Applications and disadvantages of micropropagation.</p> <p>Somaclonal Variation: History, Basis of somaclonal variations, Isolation of somaclonal variants, Factors affecting production of somaclonal variants, Applications and limitations of somaclonal variation.</p>			
Module 3:	<p>Germplasm Conservation and Cryopreservation: Modes of conservation, Cryopreservation: Techniques of cryopreservation, cryobank, Pollen bank; Prospects in agricultural and forest biotechnology.</p> <p>Production of Haploid Plants: In vitro and in vivo approaches, Androgenesis: Anther culture, Pollen culture, Development of androgenic haploids, Factors affecting androgenesis; Gynogenesis; Bulbosum method; Diploidization of haploid plants; Pollen as a tool in crop improvement, Pollen storage, Effect of radiation on pollen; Applications and limitations of haploids.</p>	12	CO3, CO4	K1, K2, K3
Module 4:	<p>Protoplast Culture and Somatic Hybridization: Isolation of protoplasts: Mechanical and Enzymatic methods; Purification of protoplasts; Viability and plating density of protoplast; Culture of protoplasts; Regeneration of protoplasts; Sub protoplasts; Somatic hybridization: Fusion of protoplasts, Selection of hybrid cells, identification of hybrid (cells) plants, Chromosome number in somatic hybrids; Cytoplasmic hybrids or Cybrids; Genetic modification of protoplasts; Application and limitations of somatic hybridization.</p> <p>Application of Biotechnology in Agriculture, Forestry and human welfare: Marker assisted selection (MAS); Production of Biopesticides; Environmental and Enzyme biotechnology.</p>	11	CO5, CO6	K4, K5
Pedagogy:	Lectures/Assignments/Seminars/Group Discussions			
Text Books:	<ol style="list-style-type: none"> 1. Aguilar Cristobel Noe (2008). <i>Food Science and Food Biotechnology in Developing countries</i>. Asiatech Publishers Inc. 2. Bhojwani, S. S. and Razdan, M. K. (1997). <i>Plant Tissue Culture: Theory and Practice</i>. Springer Publishers 			

	<p>Netherlands.</p> <ol style="list-style-type: none"> 3. Chawla, H. S. (2024). <i>Introduction to plant biotechnology</i> (4th ed.). CBS Publishers and Distributors Pvt. Ltd. 4. Dubey, R. C. (2009). <i>A text book of Biotechnology</i>. S. Chand & Co. Ltd. New Delhi. 5. Gautam, H. (2006). <i>Agricultural & Industrial Applications of Biotechnology</i>. Rajat Publication. 6. Gupta, N. K., & Gupta, S. (2023). <i>Fundamentals of plant biochemistry and biotechnology</i>. Kalyani Publishers. 7. Harikumar, V.S. (2006). <i>Advances in Agricultural Biotechnology</i>. Regency Publishers. 8. Kumar, H.D. (2005). <i>Agricultural Biotechnology</i>. Daya Publishing House. 9. Prasad (2008). <i>Biotechnology in Sustainable Biodiversity and Food Security</i>. India Book House Limited. 10. Prasad, B. D., Sahni, S., Kumar, P., & Siddiqui, M. W. (2017). <i>Plant biotechnology, volume 1: Principles, techniques, and applications</i>. Apple Academic Press, NY. 11. Rajmohan Joshi (2006). <i>Agricultural Biotechnology</i>. Gyan Books. 12. Singh, B. D. (2022). <i>Plant biotechnology</i> (4th ed.). MedTech Publishers.
References/ Readings:	<ol style="list-style-type: none"> 1. Bhavneet Kaur, et al. (2008). <i>Current Topics in Biotechnology</i>. M.D. Publications, New Delhi. 2. Park, S. (2021). <i>Plant Tissue Culture: Techniques and Experiments</i>. Academic Press. 3. Vibha Dhawan (2008). <i>Biotechnology for Food and Nutritional Security</i>. Teri Press.

Title of the Course	Lab in Plant Tissue Culture
Course Code	BOT-5202
Number of Credits	1
Theory/Practical	Practical
Level	400
Effective from AY	2025-26
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Corresponding theory course (BOT-5201)		
Course Objectives:	<ul style="list-style-type: none"> To provide hands-on training in essential techniques of plant tissue culture. Enable students to acquire skills relevant to plant propagation and crop improvement in Plant Biotechnology. 		
Course Outcomes:	Students will be able to:	Mapped to PSO	
	CO 1. Recall and explain fundamentals of sterilization and media preparation.	PSO1	
	CO 2. Apply tissue culture methods in propagation of explants and plant-based industry.	PSO3	
	CO 3. Analyze and assess various plant cell cultures, isolated protoplast for understanding cellular responses and the viability.	PSO3, PSO2	
	CO 4. Design and create plant cell cultures essential for further plant research and for sustainable bioresource utilization.	PSO3, PSO4	
Content:		No of	Mapped Cognitive

		hours	to CO	Level
Module 1:	1.1 Introduction to physical and chemical sterilization methods and lab safety. 1.2 Preparation of MS (Murashige and Skoog) medium. 1.3 Preparation of explants and surface sterilization. 1.4 Basic explant culture: leaf, node and internode cultures.	10	CO1, CO2	K1, K2, K3
Module 2:	2.1 <i>In vitro</i> Embryo and Anther culture (<i>Pisum sativum</i> , <i>Datura</i>). 2.2 Seed culture for propagation. 2.3 Callus initiation and subculturing. 2.4 Establishment of cell suspension cultures. 2.5 Viability tests using Trypan blue or fluorescein dyes.	10	CO2, CO3	K3, K4, K5
Module 3:	3.1 Protoplast isolation: enzymatic and mechanical methods. 3.2 Protoplast fusion and viability assays. 3.3 Preparation of synthetic seeds using sodium alginate encapsulation. 3.4 Regeneration of shoots from callus. 3.5 Root organ culture (ROC) techniques.	10	CO3, CO4	K4, K5, K6
Pedagogy:	Hands-on Practicals, Assignments			
Text Books:	1. Aguilar Cristobel Noe (2008). Food Science and Food Biotechnology in Developing countries. Asiatech Publishers Inc. 2. Bhavneet Kaur, et al. (2008). Current Topics in Biotechnology. M.D. Publications, New Delhi. 3. Bhojwani, S.S. and Razdan, M.K. (1997). Plant Tissue Culture: Theory and Practice. Springer Publishers Netherlands. 4. Dubey, R.C. (2009). A text book of Biotechnology. S. Chand & Co. Ltd. New Delhi. 5. Gautam, H. (2006). Agricultural & Industrial Applications of Bio- technology. Rajat Publication. 6. Gayatri, M. C., & Kavyashree, R. (2015). Plant tissue culture: protocols in plant biotechnology. Oxford : Alpha Science Intl. 7. Harikumar, V.S. (2006). Advances in Agricultural Biotechnology. Regency Publishers. 8. Kumar, H.D. (2005). Agricultural Biotechnology. Daya Publishing House.			

	<p>9. Rajmohan Joshi (2006). Agricultural Biotechnology. Gyan Books.</p> <p>10. Park, S.(2021). Plant Tissue Culture: Techniques and Experiments. Academic Press.</p> <p>11. Prasad (2008). Biotechnology in Sustainable Biodiversity and Food Security. India Book House Limited.</p> <p>12. Vibha Dhawan (2008). Biotechnology for Food and Nutritional Security. Teri Press.</p>
References/ Readings:	<p>1. Chimdessa, E. (2020). Composition and preparation of plant tissue culture medium. J. Tissue Cult. Bioeng, 3, 281-286.</p> <p>2. Pamies, D., Leist, M., Coecke, S., Bowe, G., Allen, D., Gstraunthaler, G., ... & Stacey, G. (2022). Guidance document on good cell and tissue culture practice 2.0 (GCCP 2.0).</p> <p>3. Sahoo, L. (2007). Plant biotechnology lab. manual. transformation, 14, 14.</p> <p>4. Weiskirchen, S., Schröder, S. K., Buhl, E. M., & Weiskirchen, R. (2023). A beginner's guide to cell culture: Practical advice for preventing needless problems. Cells, 12(5), 682.</p>
Web Resources:	<p>1. https://vlab.amrita.edu/index.php?sub=3</p> <p>2. https://www.ncbi.nlm.nih.gov/books</p>

Title of the Course	Plant Biochemistry
Course Code	BOT-5203
Number of Credits	3
Theory/Practical	Theory
Level	400
Effective from AY	2025-2026
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	<ul style="list-style-type: none"> ● To provide a comprehensive understanding of the chemical processes and structures of various biomolecules essential to plant life. ● To understand the structure, function, and metabolism of biomolecules such as carbohydrates, proteins, lipids, and nucleic acids. ● To explain enzymology, metabolic pathways, and the biochemical basis of physiological functions in plants. ● To emphasize the relevance of plant biochemistry in agriculture, biotechnology, and environmental sciences. 	
Course Outcomes:	Students will be able to:	Mapped to PSO
	CO 1. Describe the structure and function of major biomolecules such as carbohydrates, proteins, lipids, secondary metabolites and nucleic acids in	PSO1

	plants.			
	CO 2. Explain the role of enzymes in biochemical reactions and their regulatory mechanisms.		PSO1	
	CO 3. Illustrate key metabolic pathways involved in plant energy production and biosynthesis, such as glycolysis, TCA cycle, and photosynthetic carbon metabolism.		PSO1	
	CO 4. Evaluate the impact of environmental factors on plant biochemical processes and stress metabolism.		PSO1, PSO2	
Content:		No of hours	Mapped to CO	Cognitive Level
Module 1:	<p>1.1 Biomolecules: Classification, Structure, function, types and isomerism of biomolecules (carbohydrates, amino acids, proteins, lipids, nucleic acids); Organization and composition of eukaryotic cells; integration and control of cellular functions; amino acid composition of proteins; higher levels of protein organization; dynamic aspects of protein structure and protein stability.</p> <p>1.2 Plant biopolymers: Cellulose, hemicellulose, xylan and pectin. Biominerals in the plant such as phytoliths and calcium oxalate.</p> <p>1.3 Secondary metabolites: Physiological roles; Ecological and phylogenetic importance; Main secondary metabolites and their relation with primary metabolites.</p>	15	CO1	K1, K2
Module 2:	<p>2.1 Biomembranes: Physico-chemical properties of biological membranes; structure of model membrane; lipid bilayer and membrane protein diffusion; their distribution and organization; intrinsic and extrinsic proteins; transport of biomolecules across the membrane; passive and active transport; membrane pumps, ion channels, role of the membrane in cellular metabolism.</p>	15	CO1, CO4	K1, K2, K3

	<p>2.2 Bioenergetics: Thermodynamics; exergonic and endergonic reactions; redox potential; biological energy transducers; high-energy compounds; oxidative phosphorylation; ATP structure and its significance.</p> <p>2.3 Expression and signal transduction: Gene expression in eukaryotes; genetic control of enzyme synthesis; Signal transduction: cell surface receptors; G proteins coupled secondary messenger and response to environmental changes and other stimuli.</p>			
Module 3:	<p>3.1 Mechanism of enzyme action: Introduction to enzymes; Michaelis-Menten equation; mechanism of enzyme action; enzyme kinetics; co-enzymes; Isoenzymes; regulatory enzymes; enzyme inhibition; enzyme regulation; allosteric enzymes, reversible and irreversible covalent modifications of enzymes.</p> <p>3.2 Metabolic pathways and regulation: Major metabolic pathways and their regulation: Glycolysis, Citric acid cycle, ETC, β-oxidation of fatty acids, biosynthesis of amino acids; protein metabolism; purine and pyrimidine metabolism; metabolic interrelationships; biosynthesis of vitamins.</p>	15	CO1, CO2, CO3, CO4	K1, K2, K3
Pedagogy:	Lectures/Assignments/Seminars/Group Discussion			
Text Books:	<ol style="list-style-type: none"> Buchanan, Bob B (2007) Biochemistry and Molecular Biology of Plants. I K International Pvt. Ltd., New Delhi. Hans-Walter Heldt and Birgit Piechulla. (2021) Plant Biochemistry. Fifth Edition. Academic Press. Lehninger AL (2013) Principles of Biochemistry. WH Freeman and Company, New York. Nelson DL, Cox MM and Lehninger AL (2013) Principles of Biochemistry. Freeman, New York. Voet DJ, Voet JG and Pratt CW (2008) Principles of Biochemistry. John Wiley and Sons, Inc., New York. 			
References/ Readings:	<ol style="list-style-type: none"> Berg, Jeremy M (2012) Biochemistry. WH Freeman and Company, New York. Bowsher C (2008) Plant Biochemistry. Garland Science, New York. Brown TA (2018) Biochemistry. Viva Books Pvt. Ltd., New Delhi. 			

4. **Buchanan, Bob B** (2000) Biochemistry and Molecular Biology of Plants. Maryland American Society.
5. **Campbell D** (1999) Biochemistry. Saunders College Publishing, Philadelphia.
6. **Cooper GM** (2000) The Cell: A Molecular Approach. Sinauer Associates, Sunderland (MA).
7. **Davies D** (1980) The Biochemistry of Plants. Academic Press, USA.
8. **Devlin TM** (2011) Textbook of Biochemistry with Clinical Correlations. John Wiley and Sons, Inc., New York.
9. **Donald V and Judith GV** (2011) Biochemistry. John Wiley and Sons Asia Pvt. Ltd., New Jersey.
10. **Garret RH and Grisham CM** (2010) Biochemistry. Cengage Learning, Boston.
11. **Hames D** (2005) Biochemistry. Taylor and Francis, New Delhi.
12. **Heldt, Hans-Walter** (2005) Plant Biochemistry. Reed Elsevier India Pvt. Ltd., New Delhi.
13. **Heldt, Hans-Walter** (2011) Plant Biochemistry. Academic Press, Amsterdam, USA.
14. **Jones R** (2000) Biochemistry and Molecular Biology of Plants, American Society of Plant Physiologists, USA.
15. **Lodish H, Berk A, Kaiser CA, Krieger M, Bretscher A, Ploegh H, Amon A and Scott MP** (2013) Molecular Cell Biology. WH Freeman and Company, New York.
16. **Lubert S** (2002) Biochemistry. WH Freeman and Company, New York.
17. **Metzler P, David E** (2006) Biochemistry. Elsevier India Pvt. Ltd., New Delhi.
18. **Mishra SR** (2010) Plant Biochemistry. Discovery Publishing House Pvt. Ltd., New Delhi.
19. **Mishra SR** (2011) Understanding Plant Biochemistry. Discovery Publishing House Pvt. Ltd., New Delhi.
20. **Nicholas CP and Lewis S** (1999) Fundamentals of Enzymology. Oxford University Press Inc., New York.
21. **Ochs, Raymond S** (2014) Biochemistry. Jones and Bartlett Learning, Burlington.
22. **Rajan Katoch.** (2020). Fundamentals of Plant Biochemistry and Biotechnology. Kalyani Publishers, New Delhi.
23. **Sheehan M** (1994) Biochemistry and Molecular Biology. Thomas Nelson and Sons, United Kingdom.
24. **Singh SK** (2009) Plant Physiology and Biochemistry. Campus Books International, New Delhi.

	25. Voet DJ (1995) Biochemistry. John Wiley and Sons, New York.
Web Resources:	<ol style="list-style-type: none"> 1. https://cpur.in/library/Books/35.%20Fundamentals%20of%20Plant%20Biochemistry.pdf 2. http://www.esalq.usp.br/lepse/imgs/conteudo_thumb/Plant-Biochemistry-by-Heldt--2005-.pdf 3. https://archive.org/details/plantbiochemistr0000glea 4. https://archive.org/details/in.ernet.dli.2015.218803 5. https://www.sciencedirect.com/book/9780122146749/plant-biochemistry 6. https://uou.ac.in/sites/default/files/slm/BSCBO-303.pdf 7. https://www.researchgate.net/publication/357298216_PLANT_BIOCHEMISTRY 8. https://api.pageplace.de/preview/DT0400.9781000327915_A40306521/preview-9781000327915_A40306521.pdf

Title of the Course	Lab in Plant Biochemistry
Course Code	BOT-5204
Number of Credits	1
Theory/Practical	Practical
Level	400
Effective from AY	2025-2026
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Corresponding theory course (BOT-5203)	
Course Objectives:	<ul style="list-style-type: none"> To provide hands-on experience in techniques for analyzing plant biomolecules such as carbohydrates, amino acids, proteins, lipids, and nucleic acids. To train students in qualitative and quantitative estimation methods using standard biochemical protocols. 	
Course Outcomes:	Students will be able to:	Mapped to PSO
	CO 1. Demonstrate the ability to use basic biochemical techniques such as chromatography, spectrophotometry, and electrophoresis.	PSO1, PSO3
	CO 2. Estimate biomolecules like proteins, carbohydrates, lipids, and amino acids using standard quantitative methods.	PSO1, PSO3
	CO 3. Interpret experimental data to understand the biochemical composition and	PSO1, PSO3

	enzyme activity in plant tissues.			
	CO 4. Prepare accurate laboratory reports with proper documentation of observations, calculations, and data representation.		PSO3	
Content:		No of hours	Mapped to CO	Cognitive Level
	1. Extraction and estimation of proteins from plants using Lowry's method.	2	CO1, CO2, CO3, CO4	K1, K2, K3
	2. Extraction and estimation of amino acids from plants.	2	CO1, CO2, CO3, CO4	K1, K2, K3
	3. Extraction and estimation of total sugar and reducing sugars from plant samples.	4	CO1, CO2, CO3, CO4	K1, K2, K3
	4. Separation of protein by PAGE (preparation of gel, preparation of protein sample, running, development and documentation of gel).	6	CO1, CO2, CO3, CO4	K1, K2, K3
	5. Extraction and purification of lipids from leaf samples.	2	CO2, CO3, CO4	K1, K2, K3
	6. Preparation of Thin Layer Chromatography.	2	CO1, CO4	K1, K2, K3
	7. Separation of phosphoglycerolipids and neutral lipids using TLC.	4	CO1, CO2, CO3 CO4	K1, K2, K3
	8. Quantitative estimation of phospholipids and glycolipids (spectrophotometrically).	4	CO1, CO2, CO4	K1, K2, K3
	9. Activity of the amylase enzyme with respect to temperature and pH.	4	CO1, CO3, CO4	K1, K2, K3

	10. Qualitative and quantitative estimation of phenolic compounds.	4	CO1, CO2, CO4	K1, K2, K3
Pedagogy:	Hands-on Practicals/Demonstrations.			
Text Books:	<ol style="list-style-type: none"> 1. Buchanan, Bob B (2007) Biochemistry and Molecular Biology of Plants. I K International Pvt. Ltd., New Delhi. 2. Hans-Walter Heldt and Birgit Piechulla. (2021) Plant Biochemistry. Fifth Edition. Academic Press. 3. Lehninger AL (2013) Principles of Biochemistry. WH Freeman and Company, New York. 4. Nelson DL, Cox MM and Lehninger AL (2013) Principles of Biochemistry. Freeman, New York. 5. Voet DJ, Voet JG and Pratt CW (2008) Principles of Biochemistry. John Wiley and Sons, Inc., New York. 			
References/ Readings:	<ol style="list-style-type: none"> 1. Cooper, T.G. (2011) The Tools of Biochemistry. Wiley India Pvt. Ltd., New Delhi. 2. Devi, P. (2005) Principles and methods of Plant Molecular Biology, Biochemistry and Genetics. Jodhpur Agrobios, Jodhpur. 3. Harisha, S. (2006) Biotechnology Procedures and Experiments Handbook. Firewall Media, New Delhi. 4. Palmer, T. & Bonner, T. (2003) Enzymes: Biochemistry, Biotechnology, Clinical Chemistry. Woodhead Publishing House, Chichester, England. 5. Segel, I.H. (2010) Biochemical Calculations. John Wiley and Sons, California, USA. 6. Sheehan, D. (2009) Physical Biochemistry: Principles and applications. John Wiley and Sons Ltd, Chichester, England. 7. Wharton, David (1972) Experiments and Methods in Biochemistry. The Macmillan Co., London. 8. Wilson, K. & Walker, J. (2010). Principles and Techniques of Biochemistry and Molecular Biology. Cambridge University Press, UK. 			
Web Resources:	<ol style="list-style-type: none"> 1. https://archive.org/details/in.ernet.dli.2015.162564 2. https://library.sciencemadness.org/library/books/practical_plant_biochemistry.pdf 3. http://www.esalq.usp.br/lepse/imgs/conteudo_thumb/Plant-Biochemistry-by-Heldt--2005-.pdf 4. https://cpur.in/library/Books/35.%20Fundamentals%20of%20Plant%20Biochemistry.pdf 5. https://skyfox.co/wp-content/uploads/2020/12/Practical-Manual-of-Biochemistry.pdf 			

SEMESTER II

Discipline Specific Core Courses

Title of the Course	Microbiology and Plant Pathology
Course Code	BOT-5008
Number of Credits	3
Theory/Practical	Theory
Level	500
Effective from AY	2025-26
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Basic knowledge of microbiology and plant pathology.	
Course Objectives:	<ul style="list-style-type: none">• To understand the diversity, biology, and ecological significance of plant-associated microbes.• To apply and evaluate concepts of plant-microbe interactions to identify plant diseases and design effective disease management strategies.	
Course Outcomes:	Students will be able to:	Mapped to PSO
	CO 1. Understand the types of plant–microbe interactions, including both beneficial and pathogenic associations and describe their ecological, agricultural, and	PSO1

	biotechnological significance.			
	CO 2. Apply the knowledge in identifying plant-associated microbes and their biology		PSO2	
	CO 3. Analyze the molecular and physiological mechanisms of host-pathogen interactions, symptom development, and epidemiology of plant diseases		PSO3, PSO4	
	CO 4. Evaluate and design integrated disease management strategies for major crop diseases in tropical regions, incorporating principles of resistance breeding.		PSO4	
Content:		No of hours	Mapped to CO	Cognitive Level
Module 1:	<p>Introduction to Plant Microbiology</p> <p>1.1 Introduction to plant-microbe interactions: Symbiotic, pathogenic, commensal and opportunistic interactions</p> <p>1.2 Ecological and evolutionary perspectives of microbial association with plants</p> <p>1.3 Role of microbes in plant health and stress resilience</p> <p>1.4 Impact of climate change on plant-microbe interactions</p> <p>1.5 Introduction to different types of microbes associated with plants: Viruses, Bacteria, Mycoplasma, Fungi, Protozoans, Algae</p>	9	CO1	K1, K2, K3
Module 2:	<p>Plant association with bacteria and viruses</p> <p>2.1 Plant Bacteriology: Bacterial diversity and taxonomy, Endophytes, rhizosphere and phyllosphere microbiomes</p> <p>2.2 Bacteria in biogeochemical cycles Role in nitrogen fixation, phosphate solubilization, metal sequestration, and as biocontrol agents.</p> <p>2.3 Actinobacteria and actinorhizal symbiosis</p> <p>2.4 Mycoplasma and L-forms: biology and plant association</p> <p>2.5 Plant Virology: virus structure, morphology, chemical composition, Nomenclature and classification, Viroids and prions</p>	12	CO2, CO3	K2, K3, K4

	<p>2.6 Genome organization, replication of viruses, isolation and purification of plant viruses</p> <p>2.7 Ways of virus transmission: mechanical, seed, vector</p> <p>2.8 Tools in molecular virology: databases, cryptograms, viral genomics</p>			
Module 3:	<p>Mycological dimensions of plants</p> <p>3.1 Historical and modern perspectives of mycology</p> <p>3.2 Classification and biodiversity of fungi: Slime molds, Chytridiomycota, Oomycota, Zygomycota, Ascomycota, Basidiomycota, Glomeromycota</p> <p>3.3 Fungal life cycles, reproduction, physiology</p> <p>3.4 Endophytic fungi, saprobes, pathogenic fungi, Mycorrhizae</p> <p>3.5 Economic importance: Industrial uses: enzymes, alcohol, antibiotics, fermentation</p> <p>3.6 Edible/poisonous mushrooms, Fungi in green chemistry, nanobiotech, lichenology</p>	12	CO2, CO3	K2, K3, K4
Module 4:	<p>Plant Pathology, Molecular basis of Disease and Management</p> <p>4.1 History of plant pathology in India</p> <p>4.2 Symptomatology of fungal, bacterial, viral, and mycoplasmal diseases</p> <p>4.3 Disease classification and diagnostic methods</p> <p>4.4 Host-pathogen interaction: Molecular and physiological mechanisms, Enzymes, toxins, and elicitors, Susceptibility vs. resistance</p> <p>4.5 Epidemiology and disease forecasting</p> <p>4.6 Disease management: cultural, chemical, physical, and biological methods</p> <p>4.7 Resistant varieties, plant quarantine, crop rotation, Integrated Pest Management (IPM)</p> <p>4.8 Case Studies: Paddy (blast, blight, sheath rot), Jowar, sugarcane, groundnut, cotton, mango, banana, coconut</p> <p>4.9 Emerging technologies: Remote sensing in disease detection</p>	12	CO3, CO4	K4, K5, K6

	Market pathology and post-harvest diseases			
Pedagogy:	Lectures, Assignments, Moodle, Seminar, Group Discussion			
Text Books:	<ol style="list-style-type: none"> 1. Agrios, G.N. (2023). Agrios' Plant Pathology (6th ed.). Academic Press. 2. Ainsworth, G.C., Sparrow, F.K., & Sussman, A.S. (2008). Ainsworth & Bisby's Dictionary of the Fungi (10th ed.). CABI Publishing. 3. Alexopoulos, C.J., Mims, C.W., & Blackwell, M. (2007). Introductory Mycology (4th ed.). Wiley. 4. Atlas, R.M., & Bartha, R. (1998). Microbial Ecology: Fundamentals and Applications (4th ed.). Benjamin Cummings. 5. Bessey, E.A. (2020). Morphology and Taxonomy of Fungi. Alpha Editions. 6. Bilgrami, K.S., & Dube, H.C. (1990). Textbook of Modern Plant Pathology (2nd ed.) Vikas Publishing House. 7. Black, J.G., & Black, L.J. (2018). Microbiology: Principles and Explorations (10th ed.). Wiley. 8. Madigan, M.T., Bender, K.S., Buckley, D.H., Sattley, W.M., & Stahl, D.A. (2024). Brock Biology of Microorganisms (16th ed.). Pearson. 9. Burnett, J.H. (1976). Fundamentals of Mycology (2nd ed.). Edward Arnold. 10. Butler, E.J. and Jones, S. G. (1949). Plant Pathology. Mc Millan, London. 11. Dyck, V. A., Hendrichs, J., & Robinson, A. S. (2021). Sterile insect technique: principles and practice in area-wide integrated pest management (p. 1216). Taylor & Francis. 12. Harvey L., Arnold B., Zipursky S. L., Matsudaira P., Baltimore D. and Darnell, J. (2008). Molecular Cell Biology 6th ed. W. H. Freeman & Co. New York. 13. Iwasa J. and Marshall W. (2020). 9th edition, Karp's Cell and Molecular biology-concepts and experiments. John Wiley & Sons, New York. 14. Parthasarathy, S., Lakshmidevi, P., Satya, V. K., & Gopalakrishnan, C. (2024). Plant Pathology and Disease Management: principles and practices. (1st ed.) CRC Press. 15. Pelezar, M.J., Chan, E.C.S and Kreig, N.R. (2001). Microbiology- concepts and Applications. McGraw Hill, Inc. New York. 16. Prescott, M.J., Harly, J.P. and Klein Microbiology 5th (ed.), WCB Mc GrawHill, New York. 17. Rangaswamy, G. and Mahadevan, A. (2002). Diseases of Crop Plants in India. Prentice Hall of India, New 			

	Delhi. 18. Sharma, O.P. (2007). Text book of Fungi. Tata McGraw Hill, Publishing Co. Ltd. New Delhi.
References/ Readings:	<ol style="list-style-type: none"> 1. Baron, N. C., & Rigobelo, E. C. (2022). Endophytic fungi: a tool for plant growth promotion and sustainable agriculture. <i>Mycology</i>, 13(1), 39-55. 2. Belyakov, N. V., & Nikolina, N. V. (2021). Plant protection technologies: From advanced to innovative. In <i>Journal of Physics: Conference Series</i> (Vol. 1942, No. 1, p. 012072). IOP Publishing. 3. Chaudhry, V., Runge, P., Sengupta, P., Doehlemann, G., Parker, J. E., & Kemen, E. (2021). Shaping the leaf microbiota: plant–microbe–microbe interactions. <i>Journal of Experimental Botany</i>, 72(1), 36-56. 4. Hariharan, G., & Prasannath, K. (2021). Recent advances in molecular diagnostics of fungal plant pathogens: a mini review. <i>Frontiers in Cellular and Infection Microbiology</i>, 10, 600234. 5. Hyde, K. D., Chethana, K. W. T., Jayawardena, R. S., Luangharn, T., Calabon, M. S., Jones, E. B. G., ... & Lumyong, S. (2020). The rise of mycology in Asia. <i>ScienceAsia</i>, 46. 6. Nazarov, P. A., Baleev, D. N., Ivanova, M. I., Sokolova, L. M., & Karakozova, M. V. (2020). Infectious plant diseases: Etiology, current status, problems and prospects in plant protection. <i>Acta naturae</i>, 12(3), 46. 7. Rudgers, J. A., Afkhami, M. E., Bell-Dereske, L., Chung, Y. A., Crawford, K. M., Kivlin, S. N., & Nuñez, M. A. (2020). Climate disruption of plant-microbe interactions. <i>Annual review of ecology, evolution, and systematics</i>, 51(1), 561-586. 8. Zhou, J. M., & Zhang, Y. (2020). Plant immunity: danger perception and signaling. <i>Cell</i>, 181(5), 978-989.
Web Resources:	<ol style="list-style-type: none"> 1. https://www.apsnet.org/edcenter/Pages/default.aspx 2. https://www.dpvweb.net/ 3. https://www.mycobank.org/ 4. https://www.ncbi.nlm.nih.gov/datasets/genome/ 5. https://fungidb.org/fungidb/app 6. https://www.ipsdis.org/

Title of the Course	Lab in Microbiology and Plant Pathology
Course Code	BOT-5009
Number of Credits	1
Theory/Practical	Practical
Level	500
Effective from AY	2025-26
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	Yes

Pre-requisites for the Course:	Basic knowledge of microbiology and plant pathology	
Course Objectives:	<ul style="list-style-type: none"> To understand the diversity, biology, and ecological significance of plant-associated microbes; To apply and evaluate concepts of plant-microbe interactions to identify plant diseases and design effective disease management strategies. 	
Course Outcomes:	Students will be able to:	Mapped to PSO
	CO 1. Understand fundamental microbiological techniques including media preparation, sterilization, and microbial isolation from plant-associated environments.	PSO1
	CO 2. Demonstrate skills in culturing, staining, microscopy, and biochemical assays of plant-associated microbes including bacteria and fungi.	PSO2, PSO3, PSO4
	CO 3. Analyze fungal diversity, ecological succession, and physiological traits in various substrates and environmental conditions.	PSO2, PSO3

	CO 4. Evaluate disease symptoms, pathogen identity, and bioactive properties of microbes with relevance to crop health and bioresource potential.		PSO3, PSO4	
Content:		No of hours	Mapped to CO	Cognitive Level
Module 1:	<p>1.1 Preparation of media, understanding of sterilization techniques</p> <p>1.2 Isolation of phylloplane, rhizosphere, and endophytic microbes.</p> <p>1.3 Maintenance of pure cultures (phylloplane, rhizosphere, endophytes) using appropriate microbiological media.</p> <p>1.4 Morphological observation, staining and microscopy of unstained and stained specimens of isolated microbes.</p> <p>1.5 Biochemical and plant growth promoting assays of plant-associated bacteria.</p> <p>1.6 Nodulation assay in legumes and observation of Rhizobium-induced nodules</p>	10	CO1, CO2	K1, K2, K3
Module 2:	<p>2.1 Isolation (Particle-plateing technique and serial dilution) and culturing of Fungi from environmental samples on appropriate media.</p> <p>2.2 Observation of ecological succession of fungi in various habitats (terrestrial, marine, freshwater).</p> <p>2.3 Moist chamber method for decomposing substrates (dung, litter).</p> <p>2.4 Microscopic study of fungal hyphae and reproductive structures.</p> <p>2.5 Assessment of fungal growth and physiology under different conditions.</p> <p>2.6 Screening of fungi for enzyme production and antimicrobial activity.</p>	10	CO1, CO2, CO3	K1, K2, K3, K4
Module 3:	<p>3.1 Field diagnosis and collection of major plant disease specimens and exploration of databases.</p> <p>3.2 Tease mounts and hand sections and microscopic examination of fungal pathogens from plant diseased tissues.</p> <p>3.3 Koch's postulates demonstration using fungal or bacterial pathogen on a model host.</p> <p>3.4 Mini field-based project: collection, identification, and reporting of major</p>	10	CO4	K4, K5

	diseases of crop plants from Goa: cereal, vegetable, fruit, plantation crops.			
Pedagogy:	Hands-on Practicals, Field visits, Assignments and Mini projects			
Text Books:	<ol style="list-style-type: none"> 1. Agrios, G.N. (2023). Agrios' Plant Pathology (6th ed.). Academic Press. 2. Ainsworth, G.C., Sparrow, F.K., & Sussman, A.S. (2008). Ainsworth & Bisby's Dictionary of the Fungi (10th ed.). CABI Publishing. 3. Alexopoulos, C.J., Mims, C.W., & Blackwell, M. (2007). Introductory Mycology (4th ed.). Wiley. 4. Amareesan, N., Patel, P., & Amin, D. (Eds.). (2022). Practical handbook on agricultural microbiology. Springer US. 5. Atlas, R.M., & Bartha, R. (1998). Microbial Ecology: Fundamentals and Applications (4th ed.). Benjamin Cummings. 6. Bessey, E.A. (2020). Morphology and Taxonomy of Fungi. Alpha Editions. 7. Bilgrami, K.S., & Dube, H.C. (1990). Textbook of Modern Plant Pathology (2nd ed.) Vikas Publishing House. 8. Black, J.G., & Black, L.J. (2018). Microbiology: Principles and Explorations (10th ed.). Wiley. 9. Madigan, M.T., Bender, K.S., Buckley, D.H., Sattley, W.M., & Stahl, D.A. (2024). Brock Biology of Microorganisms (16th ed.). Pearson. 10. Burnett, J.H. (1976). Fundamentals of Mycology (2nd ed.). Edward Arnold. 11. Dube, H.C. (2014). An Introduction to Fungi, (4th Ed.) Scientific Publishers. 12. Dyck, V. A., Hendrichs, J., & Robinson, A. S. (2021). Sterile insect technique: principles and practice in area-wide integrated pest management (p. 1216). Taylor & Francis. 13. Harvey L., Arnold B., Zipursky S. L., Matsudaira P., Baltimore D. and Darnell, J. (2008). Molecular Cell Biology 6th ed. W. H. Freeman & Co. New York. 14. Iwasa J. and Marshall W. (2020). 9th edition, Karp's Cell and Molecular biology-concepts and experiments. John Wiley & Sons, New York. 15. Parthasarathy, S., Lakshmidevi, P., Satya, V. K., & Gopalakrishnan, C. (2024). Plant Pathology and Disease Management: principles and practices. (1st ed.) CRC Press. 16. Pelezar, M.J., Chan, E.C.S and Kreig, N.R. (2001). Microbiology- concepts and Applications. McGraw Hill, Inc. New York. 			

	<p>17. Prescott, M.J., Harley, J.P. and Klein Microbiology 5th (ed.), WCB Mc GrawHill, New York.</p> <p>18. Rangaswamy, G. and Mahadevan, A. (2002). Diseases of Crop Plants in India. Prentice Hall of India, New Delhi.</p> <p>19. Sharma, O.P. (2007). Text book of Fungi. Tata McGraw Hill, Publishing Co. Ltd. New Delhi.</p>
References/ Readings:	<ol style="list-style-type: none"> 1. Baron, N. C., & Rigobelo, E. C. (2022). Endophytic fungi: a tool for plant growth promotion and sustainable agriculture. Mycology, 13(1), 39-55. 2. Belyakov, N. V., & Nikolina, N. V. (2021). Plant protection technologies: From advanced to innovative. In Journal of Physics: Conference Series (Vol. 1942, No. 1, p. 012072). IOP Publishing. 3. Chaudhry, V., Runge, P., Sengupta, P., Doehlemann, G., Parker, J. E., & Kemen, E. (2021). Shaping the leaf microbiota: plant–microbe–microbe interactions. Journal of Experimental Botany, 72(1), 36-56. 4. Hariharan, G., & Prasannath, K. (2021). Recent advances in molecular diagnostics of fungal plant pathogens: a mini review. Frontiers in Cellular and Infection Microbiology, 10, 600234. 5. Hyde, K. D., Chethana, K. W. T., Jayawardena, R. S., Luangharn, T., Calabon, M. S., Jones, E. B. G., ... & Lumyong, S. (2020). The rise of mycology in Asia. ScienceAsia, 46. 6. Nazarov, P. A., Baleev, D. N., Ivanova, M. I., Sokolova, L. M., & Karakozova, M. V. (2020). Infectious plant diseases: Etiology, current status, problems and prospects in plant protection. Acta naturae, 12(3), 46. 7. Rudgers, J. A., Afkhami, M. E., Bell-Dereske, L., Chung, Y. A., Crawford, K. M., Kivlin, S. N., ... & Nuñez, M. A. (2020). Climate disruption of plant-microbe interactions. Annual review of ecology, evolution, and systematics, 51(1), 561-586. 8. Zhou, J. M., & Zhang, Y. (2020). Plant immunity: danger perception and signaling. Cell, 181(5), 978-989. 9. Qasim, M. (2023). Beneficial Microbes in Plant Health: From Biocontrol Agent to Plant Growth Promoting Rhizobacteria. International Journal of Research and Advances in Agricultural Sciences, 2, 39-49.
Web Resources:	<ol style="list-style-type: none"> 1. https://www.apsnet.org/edcenter/Pages/default.aspx 2. https://www.dpvweb.net/ 3. https://www.mycobank.org/ 4. https://www.ncbi.nlm.nih.gov/datasets/genome/ 5. https://fungidb.org/fungidb/app 6. https://www.ipsdis.org/ 7. https://plantwiseplusknowledgebank.org/

8. <https://wi.knaw.nl/>

Title of the Course	Plant Genetics and Breeding
Course Code	BOT-5010
Number of Credits	3
Theory/Practical	Theory
Level	500
Effective from AY	2025-26
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	Yes

Pre-requisites for the Course:	Basic knowledge of cell biology, Mendelian genetics, and plant reproductive biology.	
Course Objectives:	<ul style="list-style-type: none"> ● Introduce the principles of classical and molecular cytogenetics, with emphasis on cell division, chromosome structure, and patterns of inheritance. ● Provide conceptual understanding of mitotic and meiotic regulation, chromosome aberrations, extranuclear inheritance, and mobile genetic elements in plant systems. ● Develop foundational knowledge in plant developmental genetics, including gametogenesis, embryogenesis, and morphogenesis. ● Equip students with applied knowledge in plant breeding strategies, hybridization techniques, and breeding of economically important crops. ● Develop skills in quantitative genetics and pedigree-based analysis to support crop improvement and genetic mapping. 	
Course Outcomes:		Mapped to PSO

	CO 1. Understand classical genetic principles, chromosomal behavior, and inheritance mechanisms during mitosis and meiosis.		PSO1, PSO2	
	CO 2. Interpret the molecular regulation of the cell cycle and examine the roles of mobile genetic elements, mutations, and DNA repair in maintaining genome stability.		PSO1, PSO2	
	CO 3. Analyze gene expression patterns, epigenetic modifications, and their roles in regulating plant traits and inheritance.		PSO2	
	CO 4. Apply plant breeding methods and evaluate their effectiveness in hybrid development, crossing techniques, and crop improvement.		PSO2, PSO3, PSO4	
	CO 5. Demonstrate understanding of quantitative genetics by calculating heritability, interpreting gene interactions, and analyzing genotype × environment interactions.		PSO2, PSO3, PSO4	
	CO 6. Implement pedigree-based approaches to map QTLs and support selection strategies in breeding programs.		PSO3, PSO4	
Content:		No of hours	Mapped to CO	Cognitive Level
Module 1:	<p>Classical Genetics and Chromosome Biology</p> <p>1.1 Cell Division Basics: Overview of mitosis, meiosis, cytokinesis, astral microtubules and spindle dynamics; proteolysis in cell cycle.</p> <p>1.2 Chromosome Theory of Inheritance: Nucleus and Chromosome behaviour during mitosis & meiosis, synaptonemal complex (SC), recombination nodules; experimental proof and cytological evidence. Extra chromosomal inheritance; Plastid inheritance; Replication of CpDNA and mtDNA.</p> <p>1.3 Mendelian Principles: Dominance, segregation, independent assortment; molecular basis of dominance.</p> <p>1.4 Gene Concept & Extensions: Alleles, pseudoalleles, multiple alleles, complementation tests, codominance, incomplete dominance, gene interactions, pleiotropy, genomic imprinting, penetrance and expressivity, phenocopy.</p>	15	CO 1, CO 2, CO 3	K1, K2, K3, K4

	<p>1.5 Sex Determination and Linkage: Sex-linked, sex-limited, and sex-influenced traits; linkage and crossing over; gene mapping using recombination frequency.</p> <p>1.6 Gene Mapping Methods: Linkage maps, tetrad analysis, mapping with molecular markers, mapping using somatic cell hybrids, and mapping population development (F2, RILs, NILs).</p> <p>1.7 Structural and Numerical Chromosome Aberrations: Deletion, duplication, inversion, translocation, aneuploidy, polyploidy and their role in evolution and breeding.</p> <p>1.8 Recombination and Transposition: Homologous and non-homologous recombination; transposable elements relevant to plant systems.</p>			
Module 2:	<p>Molecular Cytogenetics and Developmental Genetics</p> <p>2.1 Chromosome Structure and Organization: Morphology, euchromatin and heterochromatin, centromeres, telomeres, karyotyping, banding techniques; special chromosomes (polytene, lampbrush, B-chromosomes).</p> <p>2.2 Advanced Regulation of Cell Cycle: Molecular control of mitosis and meiosis (cyclins, CDKs, checkpoints), cell cycle mutations, mitotic poisons.</p> <p>2.3 Extranuclear Inheritance: Chloroplast and mitochondrial DNA, maternal inheritance, biparental and paternal exceptions.</p> <p>2.4 Mobile Genetic Elements in Plants: Transposons & Retro-transposons in Plants; Mechanism of transposition; Ac-Ds, Spm, copia, Ty elements, use in gene tagging.</p> <p>2.5 Mutations and DNA Repair: Spontaneous and induced mutations, detection, types (lethal, conditional, germinal/somatic, loss/gain of function); DNA repair mechanisms (BER, NER, mismatch, SOS).</p> <p>2.6 Genetic Regulation of Floral Development: The ABC Model Overview of A, B, and C class genes and their combinatorial roles in specifying floral organ identity (sepals, petals, stamens, carpels); introduction to MADS-box gene family; variations in the model (ABCDE model) and relevance in evolutionary developmental biology.</p>	15	CO 2, CO 3	K1, K2, K3, K4

Module 3:	<p>Quantitative Genetics and Plant Breeding</p> <p>3.1 Introduction to Plant Breeding: Objectives, achievements, centers of origin and diversity; domestication and crop evolution; plant introduction and acclimatization.</p> <p>3.2 Inbreeding, Heterosis, and Genetic Basis: Inbreeding depression, genetic load, homozygous/heterozygous balance; genetic and physiological basis of heterosis; dominance and over-dominance hypotheses; hybrid vigour and its exploitation.</p> <p>3.3 Breeding Methods and Strategies: Mass selection, pure line selection, pedigree method, bulk method, backcross method, and recurrent selection; their applications and limitations.</p> <p>3.4 Distance Hybridization and Breeding Tools: Barriers to distant hybridization, embryo rescue, somaclonal variation, wide hybridization; <i>in vitro</i> techniques (anther, pollen, embryo, and meristem cultures) in breeding programs.</p> <p>3.5 Genetics and Crossing Techniques of Economically Important Crops: Wheat, rice, maize, cotton — floral biology, emasculation, pollination control, hybrid seed production.</p> <p>3.6 Quantitative Genetics: Polygenic inheritance, gene effects (additive, dominance, epistasis); genotype × environment interaction; estimation of heritability and genetic advance, Functional Genomics and Development: Molecular markers, MAS, QTL mapping, marker-trait associations, genomic selection, high-throughput genotyping.</p> <p>3.7 Pedigree-based analysis in plant breeding: Concepts of pedigree method, parentage tracing, and application in QTL mapping, heritability estimation, and selection strategies for crop improvement.</p>	15	CO 4, CO 5, CO 6	K2, K3, K4, K5, K6
Pedagogy:	Lectures, Assignment, Seminars, Group Discussion			
Text Books:	<ol style="list-style-type: none"> Benjamin Lewin (2007) Genes IX (9th Edition) Jones and Bartlett Publishers, Inc, USA Charles A., Janice F., Leland H., Leroy H., Michael G. (2023) ISE Genetics: From Genes to Genomes (8th Edition), McGraw-Hill Education, US. 			

	<ol style="list-style-type: none"> 3. James Watson (2024) <i>Molecular Biology of the GENE</i> new Multi-Colour edition (8th Edition) Affiliated East West Press, India 4. Hill J., Becker H.C., Tigerstedt P.M. (1998) <i>Quantitative and Ecological Aspects of Plant Breeding</i>, Springer-Science+Business Media, Germany. 5. Jain H.K (2020) <i>Plant Breeding: Mendelian to Molecular Approaches</i> (13th Edition), Alpha Science publisher, New Delhi 6. Kiara W. (2018) Genetics, Genomics and Breeding of Plants, Syrawood Publishing House, New York 7. Ram J.S. (1993) <i>Plant Cytogenetics</i> (2nd Edition), CRC Press, Taylor & Francis, UK 8. Ram J.S. (2021) <i>Practical Manual on Plant Cytogenetics</i>, CRC Press, Taylor & Francis, UK 9. Robert J. Brooker (2017) <i>Genetics: Analysis and Principles</i> 6th Edition, McGraw-Hill Education, US. 10. John E.B. (2016) <i>Plant Breeding: Past, Present and Future</i>, Springer Nature, New York. 11. Robert H. Tamarin (2017) <i>Principles of Genetics</i> (7th Edition), McGraw Hill Education, India 12. Saidaiah P. (2022) <i>Advances in Genetics and Plant Breeding</i> (Volume - 17), AkiNik Publications, New Delhi. 13. Snustad D. Peter, Michael J.S. (2015) <i>Principles of Genetics</i> (7th edition) John Wiley & Sons Inc., US 14. Tony H., Sonia G. (2023). <i>Plant Cytogenetics and Cytogenomics (Methods and Protocols)</i>, Humana Press, Springer, USA. 15. Venkata R.P. Reddy (2016) <i>Key Notes on Genetics and Plant Breeding</i>, Astral Publishing House, New Delhi.
References/ Readings:	<ol style="list-style-type: none"> 1. Bink, M. C. A. M., Uimari, P., Sillanpää, M., Janss, L., & Jansen, R. (2002). Multiple QTL mapping in related plant populations via a pedigree-analysis approach. <i>Theoretical and Applied Genetics</i>, 104, 751-762. 2. Broman, K. W., Gatti, D. M., Simecek, P., Furlotte, N. A., Prins, P., Sen, Š., ... & Churchill, G. A. (2019). R/qtl2: software for mapping quantitative trait loci with high-dimensional data and multiparent populations. <i>Genetics</i>, 211(2), 495-502. 3. Bowman, J. L., & Moyroud, E. (2024). Reflections on the ABC model of flower development. <i>The Plant Cell</i>, 36(5), 1334-1357. 4. Crossa, J., Campos, G. D. L., Pérez, P., Gianola, D., Burgueno, J., Araus, J. L., ... & Braun, H. J. (2010). Prediction of genetic values of quantitative traits in plant breeding using pedigree and molecular markers. <i>Genetics</i>, 186(2), 713-724. 5. Dhingani, R. M., Umrانيا, V. V., Tomar, R. S., Parakhia, M. V., & Golakiya, B. (2015). Introduction to QTL

mapping in plants. *Ann Plant Sci*, 4(04), 1072-1079.

6. **Figuroa, D. M., & Bass, H. W.** (2010). A historical and modern perspective on plant cytogenetics. *Briefings in functional genomics*, 9(2), 95-102.
7. **Khan, S.** (2015). QTL mapping: a tool for improvement in crop plants. *Res J Recent Sci*, 2277, 2502.
8. **Raman, R.** (2025). Pedigree Analysis in Medical Genetics. *Resonance*, 30(5), 601-620.
9. **Van Berloo, R., & Hutten, R. C. B.** (2005). Peditree: pedigree database analysis and visualization for breeding and science. *Journal of Heredity*, 96(4), 465-468.

Title of the Course	Lab in Plant Genetics and Breeding
Course Code	BOT-5011
Number of Credits	1
Theory/Practical	Practical
Level	500
Effective from AY	2025-26
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	Yes

Pre-requisites for the Course:	Basic knowledge of cell biology, Mendelian genetics, and plant reproductive biology.	
Course Objectives:	<ul style="list-style-type: none"> ● To impart hands-on experience in cytogenetic techniques including mitosis, meiosis, and chromosomal analysis. ● To enable students to observe and analyze chromosomal aberrations and polyploidy induction. ● To provide training in plant breeding techniques including emasculation, pollination, and hybridization. ● To develop skills in interpreting Mendelian and non-Mendelian inheritance through practical observations and simulations. ● To introduce developmental and reproductive biology in plants through floral biology and embryo/fertilization studies. 	
Course Outcomes:	Students will be able to:	Mapped to PSO
	CO 1. Understand cytogenetic techniques including mitotic and meiotic analysis,	PSO1

	karyotyping, and detection of chromosomal abnormalities.			
	CO 2. Assess the impact of mutagens and polyploidy on plant traits through analysis of provided data, microscopic observation, and interpretation of experimental results.		PSO1, PSO2	
	CO 3. Apply principles of classical and molecular genetics to solve inheritance problems and analyze gene interactions using phenotypic and statistical data.		PSO1, PSO3	
	CO 4. Observe and interpret floral structures and simulate hybridization techniques in selected crop plants to support breeding objectives.		PSO1, PSO2, PSO4	
	CO 5. Construct genetic linkage maps and calculate recombination frequencies using experimental or simulated datasets.		PSO2, PSO3	
	CO 6. Evaluate the role of centres of origin and genetic diversity in crop domestication and improvement based on field observations and literature review.		PSO1, PSO2, PSO3, PSO 4	
Content:		No of hours	Mapped to CO	Cognitive Level
	1. Squash preparation and study of mitotic stages from <i>Allium cepa</i> root tips; identification of metaphase plate and chromosome behaviour.	4	CO1	K2, K3
	2. Karyotype analysis and ideogram preparation using mitotic spreads; derivation of karyotypic formula and chromosome classification.	2	CO1	K1, K3, K4
	3. Observation of chromosomal aberrations (e.g., bridges, laggards, fragments) from pre-treated root tips or slides of <i>Rheo</i> sp.	2	CO1, CO2	K2, K4
	4. Study of meiosis in flower buds of <i>Allium cepa/ Rheo discolor</i> ; observation of bivalents, chiasmata, and stages of meiotic division.	4	CO1	K1, K3

	5. Induction of polyploidy using Colchicine in <i>Trigonella foenum-graecum</i> / <i>Vigna</i> sp.; assessment of phenotypic effects.	4	CO2	K3, K4
	6. Evaluation of mutagenic effects (using EMS/SA/NaOCI/UV/Ethanol stress) on germination, morphology, and seedling traits in <i>Brassica juncea</i> / <i>Oryza sativa</i> .	4	CO2	K4, K5
	7. Floral biology of <i>Oryza sativa</i> and emasculation techniques; identification of floral whorls and pollen/ovule traits.	2	CO4	K2, K4
	8. Floral biology and hybridization techniques in <i>Zea mays</i> / <i>Saccharum spp.</i> (Sugarcane); bagging, tagging, and pollen collection.	4	CO4	K2, K3
	9. Demonstration and practice of artificial hybridization techniques in <i>Oryza sativa</i> / <i>Zea mays</i> .	2	CO4	K3, K4
	10. Construction of gene linkage maps using recombination data (simulation or case dataset); calculation of map distances.	2	CO5	K3, K4
	11. Construction and Interpretation of Pedigree Charts for Monogenic and Sex-Linked Inheritance Patterns (Simulated Data)	2	CO1, CO3	K2, K4
	12. Analysis of centres of origin and diversity of selected crops using morphological traits and literature survey.	2	CO6	K2, K5, K6
	13. Analysis of Gene Interactions through Case-Based Problems and Punnett Square Calculations	2	CO2, CO4, CO6	K2, K4, K5
	14. Interpretation of RAPD Banding Patterns Using Simulated Gel Images and Calculation of Polymorphism Metrics	4	CO2, CO3	K2, K4, K6
	<i>Only 30 hours of any of the above practicals will be conducted depending on availability of plant materials.</i>			
Pedagogy:	Hands-on Practical, Group Discussions, Demonstrations, Field visits, Assignments and Mini projects			

<p>Text Books:</p>	<ol style="list-style-type: none"> 1. Benjamin Lewin (2007) <i>Genes IX</i> (9th Edition) Jones and Bartlett Publishers, Inc, USA 2. Charles A., Janice F., Leland H., Leroy H., Michael G. (2023) <i>ISE Genetics: From Genes to Genomes</i> (8th Edition), McGraw-Hill Education, US. 3. James Watson (2024) <i>Molecular Biology of the GENE new Multi-Colour edition</i> (8th Edition) Affiliated East West Press, India 4. Hill J., Becker H.C., Tigerstedt P.M. (1998) <i>Quantitative and Ecological Aspects of Plant Breeding</i>, Springer-Science+Business Media, Germany. 5. Jain H.K (2020) <i>Plant Breeding: Mendelian to Molecular Approaches</i> (13th Edition), Alpha Science publisher, New Delhi 6. Kiara W. (2018) Genetics, Genomics and Breeding of Plants, Syrawood Publishing House, New York 7. Ram J.S. (1993) <i>Plant Cytogenetics</i> (2nd Edition), CRC Press, Taylor & Francis, UK 8. Ram J.S. (2021) <i>Practical Manual on Plant Cytogenetics</i>, CRC Press, Taylor & Francis, UK 9. Robert J. Brooker (2017) <i>Genetics: Analysis and Principles</i> 6th Edition, McGraw-Hill Education, US. 10. John E.B. (2016) <i>Plant Breeding: Past, Present and Future</i>, Springer Nature, New York. 11. Robert H. Tamarin (2017) <i>Principles of Genetics</i> (7th Edition), McGraw Hill Education, India 12. Saidaiah P. (2022) <i>Advances in Genetics and Plant Breeding</i> (Volume - 17), AkiNik Publications, New Delhi. 13. Snustad D. Peter, Michael J.S. (2015) <i>Principles of Genetics</i> (7th edition) John Wiley & Sons Inc., US 14. Tony H., Sonia G. (2023). <i>Plant Cytogenetics and Cytogenomics (Methods and Protocols)</i>, Humana Press, Springer, USA. 15. Venkata R.P. Reddy (2016) <i>Key Notes on Genetics and Plant Breeding</i>, Astral Publishing House, New-Delhi.
<p>References/ Readings:</p>	<ol style="list-style-type: none"> 1. Bink, M. C. A. M., Uimari, P., Sillanpää, M., Janss, L., & Jansen, R. (2002). Multiple QTL mapping in related plant populations via a pedigree-analysis approach. <i>Theoretical and Applied Genetics</i>, 104, 751-762. 2. Broman, K. W., Gatti, D. M., Simecek, P., Furlotte, N. A., Prins, P., Sen, Š., ... & Churchill, G. A. (2019). R/qt12: software for mapping quantitative trait loci with high-dimensional data and multiparent populations. <i>Genetics</i>, 211(2), 495-502.

	<ol style="list-style-type: none"> 3. Bowman, J. L., & Moyroud, E. (2024). Reflections on the ABC model of flower development. <i>The Plant Cell</i>, 36(5), 1334-1357. 4. Crossa, J., Campos, G. D. L., Pérez, P., Gianola, D., Burgueno, J., Araus, J. L., ... & Braun, H. J. (2010). Prediction of genetic values of quantitative traits in plant breeding using pedigree and molecular markers. <i>Genetics</i>, 186(2), 713-724. 5. Dhingani, R. M., Umrانيا, V. V., Tomar, R. S., Parakhia, M. V., & Golakiya, B. (2015). Introduction to QTL mapping in plants. <i>Ann Plant Sci</i>, 4(04), 1072-1079. 6. Figuroa, D. M., & Bass, H. W. (2010). A historical and modern perspective on plant cytogenetics. <i>Briefings in functional genomics</i>, 9(2), 95-102. 7. Khan, S. (2015). QTL mapping: a tool for improvement in crop plants. <i>Res J Recent Sci</i>, 2277, 2502. 8. Raman, R. (2025). Pedigree Analysis in Medical Genetics. <i>Resonance</i>, 30(5), 601-620. 9. Van Berloo, R., & Hutten, R. C. B. (2005). Peditree: pedigree database analysis and visualization for breeding and science. <i>Journal of Heredity</i>, 96(4), 465-468.
<p>Web Resources:</p>	<ol style="list-style-type: none"> 1. Bink, M. C. A. M., Uimari, P., Sillanpää, M., Janss, L., & Jansen, R. (2002). Multiple QTL mapping in related plant populations via a pedigree-analysis approach. <i>Theoretical and Applied Genetics</i>, 104, 751-762. 2. Broman, K. W., Gatti, D. M., Simecek, P., Furlotte, N. A., Prins, P., Sen, Š., & Churchill, G. A. (2019). R/qtl2: software for mapping quantitative trait loci with high-dimensional data and multiparent populations. <i>Genetics</i>, 211(2), 495-502. 3. Bowman, J. L., & Moyroud, E. (2024). Reflections on the ABC model of flower development. <i>The Plant Cell</i>, 36(5), 1334-1357. 4. Crossa, J., Campos, G. D. L., Pérez, P., Gianola, D., Burgueno, J., Araus, J. L., ... & Braun, H. J. (2010). Prediction of genetic values of quantitative traits in plant breeding using pedigree and molecular markers. <i>Genetics</i>, 186(2), 713-724. 5. Dhingani, R. M., Umrانيا, V. V., Tomar, R. S., Parakhia, M. V., & Golakiya, B. (2015). Introduction to QTL mapping in plants. <i>Ann Plant Sci</i>, 4(04), 1072-1079. 6. Figuroa, D. M., & Bass, H. W. (2010). A historical and modern perspective on plant cytogenetics. <i>Briefings in functional genomics</i>, 9(2), 95-102. 7. Khan, S. (2015). QTL mapping: a tool for improvement in crop plants. <i>Res J Recent Sci</i>, 2277, 2502.

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| | <ol style="list-style-type: none">8. Raman, R. (2025). Pedigree Analysis in Medical Genetics. <i>Resonance</i>, 30(5), 601-620.9. Van Berloo, R., & Hutten, R. C. B. (2005). Pedigree: pedigree database analysis and visualization for breeding and science. <i>Journal of Heredity</i>, 96(4), 465-468. |
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Title of the Course	Plant Molecular Biology
Course Code	BOT-5012
Number of Credits	3
Theory/Practical	Theory
Level	500
Effective from AY	2025-2026
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	Yes

Pre-requisites for the Course:	Basic knowledge of Plant Molecular Biology.	
Course Objectives:	<ul style="list-style-type: none"> ● To provide foundational knowledge of molecular mechanisms governing gene structure, expression, and regulation in plants. ● To understand DNA replication, transcription, translation, gene expression, molecular biology of recombination, and processing of various RNA molecules. ● To highlight its applications in crop improvement and biotechnology. 	
Course Outcomes:	Students will be able to:	Mapped to PSO
	CO 1. Describe the fundamental concepts of nucleic acid structure and the central dogma of molecular biology in plants	PSO1
	CO 2. Explain the molecular mechanisms of DNA replication, transcription, translation, and gene regulation in plant cells.	PSO1, PSO2

	CO 3. Discuss the mechanisms of genetic recombination, mutation, and repair in plants.		PSO1, PSO2	
	CO 4. Evaluate the significance of molecular tools in plant biotechnology and crop improvement		PSO1, PSO3	
Content:		No of hours	Mapped to CO	Cognitive level
Module 1:	<p>1.1. Introduction to Molecular Genetics and Genomics: History of DNA molecule & discoveries till date. Human Genome Project. Physical nature of DNA: DNA is the genetic material, Chemical nature of DNA: Structure of nucleotides, Bonding, double helix and other helices; Repetitive DNA, Factors affecting DNA structure. Organization of DNA.</p> <p>1.2. Molecular Biology of DNA Replication: Enzymes involved in replication, DNA replication is semi-conservative, Messelson-Stahl experiment, Multiple Origins & bi-directional DNA replication in Eukaryotes, Unwinding, Stabilization & Stress relief, initiation by a Primosome complex, Replisomes, Chain elongation & Proofreading, discontinuous replication of the lagging strand, Telomerase, Terminator sequencing of DNA. Theta replication of Circular DNA molecules; Rolling Circle replication of plasmid DNA; Replication of Viruses.</p>	15	CO1, CO2	K1, K2, K3
Module 2:	<p>2.1. Molecular Biology of Recombination: Molecular mechanisms of Recombination, homologous and site-specific recombination, Gene conversion, Mismatch repair, Holliday model of recombination, DNA damage and repair mechanisms: Single strand break, double strand breaks & repair model.</p> <p>2.2. Transcription: Enzymes in transcription; Basic features of transcription, Initiation, elongation and termination, RNA polymerases, promoters and enhancers; transcription activator and repressor; transcription factors, prokaryotic and eukaryotic transcription.</p> <p>2.3. RNA Molecules and RNA Processing: Gene structure, Structure & Processing of messenger RNA, transfer RNA, ribosomal RNA, small interfering RNAs & micro RNAs, regulation through RNA processing & decay, alternative splicing, capping, polyadenylation, RNA transport, mRNA stability; RNA</p>	15	CO1, CO2, CO3	K1, K2, K3

	interference (RNAi).			
Module 3:	<p>3.1. Regulation of Gene Expression: Regulation of gene expression in prokaryotes and Eukaryotes. Expression of lac operon: Lac operon and Tryp operon; Transcriptional Control I, Transcriptional Control II, Attenuation, Antitermination, Methylation, alteration of gene expression by DNA sequence rearrangements.</p> <p>3.2. The Genetic Code and Translation: Molecular relation between Genotype & Phenotype, The Genetic Code, Factors involved in initiation, elongation and termination of translation, aminoacylation of tRNA, amino acyl tRNA synthetase, Post-translational processing and modification, Transport of protein across the membrane.</p> <p>3.3. Techniques in Molecular Biology: Electrophoresis, dot & slot blots; blotting (Southern, Northern, Western), RFLP, RAPD, Different types of PCR; DNA sequencing methods, DNA fingerprinting, protein sequencing- MALDI.</p>	15	CO2, CO4	K1, K2, K3
Pedagogy:	Lectures/Assignments/Seminars/ Group Discussions.			
Text Books:	<ol style="list-style-type: none"> Benjamin Lewin. (2008) GENES IX. Jones and Bartlett Publishers, London, UK. Freifelder D. (1990) Molecular Biology. Second Edition. Narosa Publishing House, New Delhi. Old R.W. and Primerose S. B. (1980) Principles of Gene Manipulation. An Introduction to Genetic Engineering. Blackwell Scientific Publishers. Tewari, K.K. and Singhal, G.S. (1997) Plant Molecular Biology and Biotechnology. Narosa Publishing House, New Delhi. Tropp. B.E. (2012) Molecular Biology. Fourth Edition. Jones and Bartlett India Pvt. Ltd, New Delhi. Watson J.D., Baker T.A., Bell S.P., Gann A., Levine M & Losick R (2008) Molecular Biology of Gene. Sixth Edition. Cold Spring Harbor Laboratory Press, Cold Spring Harbor, New York. U.S.A. 			
References/ Readings:	<ol style="list-style-type: none"> Brown T. A. (2007) Genomes. Third Edition. Garland Science Publishing, New York. U.S.A. Coruzzi G. (1994) Plant Molecular Biology - Genetic Analysis of Plant Development and Metabolism. Springer-Verlag, New York, London Grierson D and S. Covey. (1984) Plant Molecular Biology. Panima Educational Agency, New Delhi. 			

	<ol style="list-style-type: none"> 4. Henry R. J. (2005) Practical Applications of Plant Molecular Biology. Chapman & Hall, London, UK. 5. Goldstein E.S., Krebs J.E., Kilpatrick S.T. (2011) Lewin's GENES X. Oxford University Press. 6. Primrose, S. B. and R. M. Twyman. (2009) Principles of Gene Manipulation and Genomics. Seventh Edition. Blackwell Publishing, U.S.A. 7. Schuler M.A.Z., and Raymond E.Z. (2005) Methods in Plant Molecular Biology. Academic Press, USA. 8. Shaw, C.H. (1988) Plant Molecular Biology, Practical Approach. IRL Press, Oxford, Washington DC.
Web Resources:	<ol style="list-style-type: none"> 1. https://link.springer.com/book/10.1007/978-94-010-9649-2 2. https://www.academia.edu/56375406/Plant_Molecular_Biology_Manual 3. https://annamalaiuniversity.ac.in/studport/download/agri/gen/resources 4. https://www.scribd.com/document/807410619/Full-Download-Plant-Genetics-and-Molecular-Biology-Rajeev-K-Varshney-PDF-DOCX 5. https://www.researchgate.net/publication/343474122 Fundamentals of Molecular Biology and Plant Biotechnology 6. https://www.freebookcentre.net/biology-books-download/The-Molecular-Biology-of-Plant-Cells.html

Title of the Course	Lab in Plant Molecular Biology
Course Code	BOT-5013
Number of Credits	1
Theory/Practical	Practical
Level	500
Effective from AY	2025-2026
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	Yes

Pre-requisites for the Course:	Basic knowledge of Plant Molecular Biology.	
Course Objectives:	<ul style="list-style-type: none"> To provide hands-on training in fundamental molecular techniques such as DNA/RNA extraction, PCR, and gel electrophoresis. To develop skills in executing experiments, data analysis, and troubleshooting. 	
Course Outcomes:	Students will be able to:	Mapped to PSO
	CO 1. Perform essential molecular biology techniques such as DNA isolation, RNA extraction, and PCR amplification accurately.	PSO1, PSO3
	CO 2. Operate laboratory instruments like gel electrophoresis apparatus and spectrophotometers for molecular analysis.	PSO1, PSO3, PSO4
	CO 3. Interpret experimental data from molecular analyses, including gel documentation, spectrophotometry and PCR results.	PSO3, PSO4

	CO 4. Prepare detailed laboratory records and reports documenting methods, observations, and conclusions.		PSO3	
Content:		No of hours	Mapped to CO	Cognitive Level
	1. Isolation and purification of genomic DNA from plants using CTAB method.	4	CO1, CO2, CO4	K1, K2
	2. Isolation and purification of RNA from plants.	4	CO1, CO2, CO4	K1, K2
	3. Quantitative estimation of DNA using spectrophotometric method.	2	CO1, CO2, CO3, CO4	K1, K2, K3
	4. Quantitative estimation of RNA using spectrophotometric method.	2	CO1, CO2, CO3, CO4	K1, K2, K3
	5. Quantitative estimation of RNA using Orcinol method.	4	CO1, CO2, CO3, CO4	K1, K2, K3
	6. Agarose gel electrophoresis of genomic DNA and detection using gel documentation system.	4	CO1, CO2, CO3, CO4	K1, K2, K3
	7. Deantured gel of isolated RNA and detection using gel documentation system.	4	CO1, CO2, CO3, CO4	K1, K2, K3
	8. Primer designing of gene of interest.	2	CO1, CO3, CO4	K1, K2, K3
	9. Amplification of genomic DNA using random primers in PCR and agarose gel electrophoresis and detection of the banding patterns under gel documentation system.	6	CO1, CO2, CO3, CO4	K1, K2, K3
Pedagogy:	Hands-on practicals /Demonstrations			
Text Books:	<ol style="list-style-type: none"> 1. Henry R. J. (2005) Practical Applications of Plant Molecular Biology. Chapman & Hall, London, UK. 2. Mary A. Schuler and Raymond E. Zielinski (2005) Methods in Plant Molecular Biology. Academic Press, USA. 3. Shaw, C.H. (1988) Plant Molecular Biology, Practical Approach. IRL Press, Oxford, Washington DC. 4. Vennison, D.C.S. (2009) Laboratory manual for genetic engineering. PHI Learning Pvt. Ltd. 			

<p>References/ Readings:</p>	<ol style="list-style-type: none"> 1. Burton E. Tropp. (2012) Molecular Biology. Fourth Edition. Jones and Bartlett India Pvt. Ltd, New Delhi. 2. David Freifelder. (1990) Molecular Biology. 2nd Edition. Narosa Publishing House, New Delhi. 3. Gloria Coruzzi. (1994) Plant Molecular Biology - Genetic Analysis of Plant Development and Metabolism. Springer-Verlag, New York, London. 4. Grierson D & S. Covey. (1984) Plant Molecular Biology. Panima Educational Agency, New Delhi. 5. James D.W., Tania A.B., Stephen P.B., Alexander G., Michael L. & Richard L. (2008) Molecular Biology of Gene. 29th Edition. Cold Spring Harbor Laboratory Press, Cold Spring Harbor, New York. U.S.A. 6. Neal Stewart J.C. (2008) Plant Biotech and genetics: Principle, techniques and applications. Wiley Jones and Sons, Canada 7. Primrose, S.B. & R.M. Twyman. (2009) Principles of Gene Manipulation and Genomics. Seventh Edition. Blackwell Publishing, U.S.A. 8. Tewari, K.K. & G.S. Singhal. (1997) Plant Molecular Biology and Biotechnology. Narosa Publishing House, New Delhi
<p>Web Resources:</p>	<ol style="list-style-type: none"> 1. https://www.sciencedirect.com/book/9780126323405/methods-in-plant-molecular-biology 2. https://www.academia.edu/56375406/Plant_Molecular_Biology_Manual 3. https://www.researchgate.net/publication/387306040_Laboratory_Practical_Manual_of_Plant_Molecular_Biology_and_Biotechnology_for_college_UG_and_PG_Students 4. https://archive.org/details/isbn_9780199638765 5. https://www.academia.edu/56375406/Plant_Molecular_Biology_Manual 6. https://kau.in/sites/default/files/documents/a_plant_biotechnology_laboratory_manual.pdf 7. https://link.springer.com/book/10.1007/978-3-642-87873-2

Title of the Course	Plant Genetic Engineering
Course Code	BOT-5014
Number of Credits	1
Theory/Practical	Theory
Level	500
Effective from AY	2025-26
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	Yes

Pre-requisites for the Course:	Basic knowledge of Plant Genetic Engineering	
Course Objectives:	Equip students with plant genetic engineering tools and techniques, and their application in agriculture, environment, and plant biotechnology with emphasis on ethical and regulatory considerations.	
Course Outcomes:	Students will be able to:	Mapped to PSO
	CO 1. Understand the principles of recombinant DNA technology and molecular tools used in plant genetic engineering.	PSO1, PSO3
	CO 2. Apply plant transformation methods and genome editing technologies to design genetically modified plants for desired traits.	PSO3, PSO4
	CO 3. Analyze gene regulation mechanisms and genome editing strategies to investigate plant gene function.	PSO2, PSO3
	CO 4. Design of synthetic gene circuits and evaluate the biosafety, ethical, and regulatory	PSO2, PSO4

	aspects of GM crops.			
Content:		No of hours	Mapped to CO	Cognitive Level
Module 1:	<p>Foundations of Plant Genetic Engineering and recombinant DNA technology</p> <p>1.1 Introduction to genetic engineering and RDT in plant sciences: Applications in agriculture, environment. Conventional breeding vs. genetic engineering.</p> <p>1.2 Basic principles of DNA manipulation: Restriction-modification systems, DNA modifying enzymes, restriction enzymes, ligation strategies.</p> <p>1.3 DNA vector structure and properties, Plasmids, Bacteriophages, Cosmids, ssDNA and dsDNA vectors, vector-host systems.</p> <p>1.4 Genome and cDNA library construction</p> <p>1.5 Gene cloning techniques, selection strategies for transformants</p> <p>1.6 Molecular Markers: RFLP, AFLP, RAPD, SSRs for transgene confirmation.</p>	9	CO1	K1, K2, K3
Module 2:	<p>Plant Transformation and Molecular Tools</p> <p>2.1 Agrobacterium biology: Ti plasmid, T-DNA, Vir genes, Binary and Co-integrate vectors: detailed mechanisms in Agrobacterium.</p> <p>2.2 Direct gene transfer methods, Electroporation, biolistics, PEG-mediated transfer and horizontal gene transfer in plants.</p> <p>2.3 Site-directed mutagenesis: Principles and techniques</p> <p>2.4 DNA sequencing strategies: Sanger, NGS</p> <p>2.5 Plant genome organization: Nuclear, mitochondrial, and chloroplast genomes, transcription, translation, retrograde signaling, organelle-specific genetic codes</p> <p>2.6 Chloroplast transformation: advantages and techniques.</p> <p>2.7 Gene stacking and multigene engineering for complex traits</p>	12	CO1, CO2	K3, K4
Module 3:	<p>Gene Regulation and Functional Genomics in Plants</p> <p>3.1 Gene expression technologies: PCR, RT-PCR, qPCR, microarrays</p> <p>3.2 Gene silencing and regulation: Antisense RNA, RNAi Mutants in silencing,</p>	12	CO3, CO4	K4, K5, K6

	<p>VIGS</p> <p>3.3 Genome editing technologies: TALENs, ZFNs, CRISPR-Cas9 mechanism and applications.</p> <p>3.4 Promoter Analysis and Enhancer Elements: Plant-specific regulatory elements</p> <p>3.5 Synthetic Biology Approaches: Design of synthetic gene circuits in plants</p>			
Module 4:	<p>Applications, Ethics, and Biosafety</p> <p>4.1 Genetically modified (GM) crops: Traits engineered (herbicide, pest, stress resistance), Case studies: Bt cotton, Golden rice, etc. biofortified crops, edible vaccines and biopharming.</p> <p>4.2 Genome projects: Rice, maize, wheat.</p> <p>4.3 Socio-environmental and ethical issues: Public perception and controversies.</p> <p>4.4 Food safety, labeling, regulatory frameworks, Indian regulatory context: DBT, GEAC, biosafety protocols, Cartagena Protocol on Biosafety.</p> <p>4.5 Field testing and containment procedures.</p> <p>4.6 Gene drive technology overview and applications.</p>	12	CO4	K4, K5, K6
Pedagogy:	Lectures, interactive discussions, seminar, assignments, Moodle			
Text Books:	<ol style="list-style-type: none"> Armstrong, C. L., Spencer, T. M., Stephens, M. A., & Brown, S. M. (2000). Transgenic maize. In L. O'Brien & R. J. Henry (Eds.), <i>Transgenic cereals</i> (pp. 49–70). American Association of Cereal Chemists. Coruzzi, G., & Puigdomènech, P. (Eds.). (1994). <i>Plant molecular biology: Genetic analysis of plant development and metabolism</i> (1st ed.). Springer-Verlag. https://doi.org/10.1007/978-3-642-78418-2. Grumezescu, A. M., & Holban, A. M. (Eds.). (2017). <i>Genetically engineered foods</i> (Vol. 6). Academic Press. https://doi.org/10.1016/C2015-0-04529-6 Grierson, D., & Covey, S. N. (1984). <i>Plant molecular biology</i> (1st ed.). Panima Educational Agency. Freifelder, D. (1987). <i>Molecular biology</i> (2nd ed.). Narosa Publishing House. Isaacson, W. (2022). <i>The code breaker-Young readers edition: Jennifer Doudna and the race to understand our genetic code</i> (1st ed.). Simon & Schuster Books for Young Readers. Lewin, B. (1999). <i>Genes VII</i> (7th ed.). Oxford University Press. 			

	<p>8. Lynas, M. (2018). Seeds of science: Why we got it so wrong on GMOs (1st ed., Vol. 34). Bloomsbury Publishing.</p> <p>9. Old, R. W., & Primrose, S. B. (1980). Principles of gene manipulation: An introduction to genetic engineering (1st ed.). Blackwell Scientific Publications.</p> <p>10. Pahara, J., & Legault, J. (2021). Zero to genetic engineering hero (2nd ed.). Make Community.</p> <p>11. Patrick, F. (2018). Genetic engineering: Emerging concepts and technology (1st ed.). Syrawood Publishing House.</p> <p>12. Shaw, C. H. (Ed.). (1988). Plant molecular biology: A practical approach (1st ed.). IRL Press.</p> <p>13. Tewari, K. K., & Singhal, G. S. (1997). Plant molecular biology and biotechnology (1st ed.). Narosa Publishing House.</p>
References/ Readings:	<p>1. Barampuram, S., & Zhang, Z. J. (2023). Plant genetic transformation: Achievements, current status, and future outlook. <i>Frontiers in Plant Science</i>, 14, 12120897. https://doi.org/10.3389/fpls.2023.12120897</p> <p>2. Kumar, P., Pandey, K. D., & Shukla, P. (2019). Genetic engineering for disease resistance in plants. <i>3 Biotech</i>, 9(3), 143. https://doi.org/10.1007/s13205-019-1687-7</p> <p>3. Tripathi, L., Ntui, V. O., & Tripathi, J. N. (2022). Genetically engineered crops for sustainably enhanced food production. <i>Frontiers in Plant Science</i>, 13, 1027828. https://doi.org/10.3389/fpls.2022.1027828</p> <p>4. Zhang, Z., Lin, Q., & Liu, H. (2022). Recent advances in plant genetic engineering and innovative applications. <i>Frontiers in Plant Science</i>, 13, 1045417. https://doi.org/10.3389/fpls.2022.1045417</p>
Web Resources:	<p>1. https://geneticliteracyproject.org</p> <p>2. https://www.fao.org/biotech/en/</p> <p>3. https://www.isaaa.org/kc/default.asp</p>

Title of the Course	Lab in Plant Genetic Engineering
Course Code	BOT-5015
Number of Credits	1
Theory/Practical	Practical
Level	500
Effective from AY	2025-26
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	Yes

Pre-requisites for the Course:	Basic knowledge of Plant Genetic Engineering.	
Course Objectives:	<ul style="list-style-type: none"> • Equip students with foundational and advanced knowledge of plant genetic engineering, • Enable students to understand, apply, and innovate molecular techniques for gene manipulation, transformation, and expression analysis in plants. 	
Course Outcomes:	Students will be able to:	Mapped to PSO
	CO 1. Understand the molecular tools, techniques and principles used in plant genetic engineering.	PSO1, PSO3
	CO 2. Apply molecular tools and techniques for isolation, amplification and manipulations of plant genes.	PSO3
	CO 3. Analyze and validate genetic transformations using appropriate molecular biology tools and techniques.	PSO1, PSO3

	CO 4. Design and construct recombinant DNA molecules for targeted applications in plant genetic engineering.		PSO3, PSO4	
Content:		No of hours	Mapped to CO	Cognitive Level
Module 1:	<p>Foundational Techniques in Plant Genetic Engineering</p> <p>1.1 Culture and maintenance of plasmid-containing bacterial cultures and understanding of the vector map of plasmid.</p> <p>1.2 Isolation of plasmid DNA.</p> <p>1.3 Quantitative estimation of plasmid DNA using spectrophotometer.</p> <p>1.4 Qualitative estimation of plasmid DNA using Agarose gel electrophoresis.</p>	8	CO1, CO2,	K2, K3
Module 2:	<p>Amplification, Gene cloning and Transformation</p> <p>2.1 Preparation of <i>E. coli</i> (Dh5α) competent cells</p> <p>2.2 Primer designing for gene amplification and RT PCR</p> <p>2.3 Amplification of gene of interest for cloning</p> <p>2.4 Digestion of plasmid DNA and gene of interest with restriction enzymes and size fractionation.</p> <p>2.5 Ligation of digested DNA fragments.</p> <p>2.6 Transformation of ligated plasmid in competent cells.</p> <p>2.7 Screening of transformed bacterial cells by colony PCR.</p> <p>2.8 Agrobacterium mediated leaf disc transformation and regeneration of plants.</p>	14	CO1, CO2, CO3, CO4	K3, K4, K5, K6
Module 3:	<p>Gene expression studies and blotting</p> <p>3.1 cDNA synthesis using reverse transcriptase.</p> <p>3.2 RT-PCR quantification of selected gene(s).</p> <p>3.3 Use of software for gene expression quantification and comparative analysis.</p> <p>3.4 Blotting techniques: Southern/Northern/Western blotting (any one).</p>	8	CO1, CO2, CO3	K2, K3, K4, K5
Pedagogy:	Hands-on practicals, demonstrations			

Text Books:	<ol style="list-style-type: none"> 1. Old, R. W., & Primrose, S. B. (1980). Principles of gene manipulation: An introduction to genetic engineering (1st ed.). Blackwell Scientific Publications. 2. Pahara, J., & Legault, J. (2021). Zero to genetic engineering hero (2nd ed.). Make Community. 3. Patrick, F. (2018). Genetic engineering: Emerging concepts and technology (1st ed.). Syrawood Publishing House. 4. Sambrook, J., & Russell, D. W. (2001). Molecular cloning: A laboratory manual (3rd ed.). Cold Spring Harbor Laboratory Press. 5. Shaw, C. H. (Ed.). (1988). Plant molecular biology: A practical approach (1st ed.). IRL Press. 6. Wilson, K., & Walker, J. (2010). Principles and techniques of biochemistry and molecular biology (7th ed.). Cambridge University Press.
References/ Readings:	<ol style="list-style-type: none"> 1. Barampuram, S., & Zhang, Z. J. (2023). Plant genetic transformation: Achievements, current status, and future outlook. <i>Frontiers in Plant Science</i>, 14, 12120897. https://doi.org/10.3389/fpls.2023.12120897 2. Kumar, P., Pandey, K. D., & Shukla, P. (2019). Genetic engineering for disease resistance in plants. <i>3 Biotech</i>, 9(3), 143. https://doi.org/10.1007/s13205-019-1687-7 3. Tripathi, L., Ntui, V. O., & Tripathi, J. N. (2022). Genetically engineered crops for sustainably enhanced food production. <i>Frontiers in Plant Science</i>, 13, 1027828. https://doi.org/10.3389/fpls.2022.1027828 4. Zhang, Z., Lin, Q., & Liu, H. (2022). Recent advances in plant genetic engineering and innovative applications. <i>Frontiers in Plant Science</i>, 13, 1045417. https://doi.org/10.3389/fpls.2022.1045417
Web Resources:	<ol style="list-style-type: none"> 1. https://www.addgene.org 2. https://openwetware.org 3. https://www.protocol-online.org 4. http://ptdb.im.ac.cn/ 5. https://www.ncbi.nlm.nih.gov

Discipline Specific Elective Courses

Title of the Course	Plant Ecology and Environment
Course Code	BOT-5205
Number of Credits	3
Theory/Practical	Theory
Level	400
Effective from AY	2025-26
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil
Course Objectives:	<ul style="list-style-type: none">● Understand fundamental and advanced concepts in population and spatial ecology, including life history strategies, population dynamics, diversity indices, and metapopulation theory.● Explore ecological interactions, community assembly, and molecular and evolutionary ecology, with emphasis on genetic diversity, species coexistence, and phylogenetic relationships.● Apply principles of species distribution modelling and spatial ecology for ecological forecasting and conservation planning.● Evaluate global change drivers and conservation strategies, including case studies relevant to Indian ecosystems and biodiversity hotspots.● Inculcate skills in environmental impact assessment and ecological economics, enabling students to assess biodiversity value, environmental trade-offs, and inform sustainable development.

Course Outcomes:	Students will be able to:	Mapped to PSO		
	CO 1. Understand and explain life history traits, population growth models, diversity indices, and metapopulation dynamics in plant ecology.	PSO1, PSO2		
	CO 2. Analyse species distribution, ecological niches, and spatial patterns using environmental niche modelling and GIS tools.	PSO2, PSO3		
	CO 3. Evaluate ecological interactions (e.g., competition, predation, mutualism), and interpret community structure using theoretical models.	PSO2, PSO3		
	CO 4. Integrate molecular ecology approaches to assess genetic structure, gene flow, and phylogeography for conservation purposes.	PSO2, PSO4		
	CO 5. Assess biodiversity loss, climate change impacts, and conservation strategies through Indian and global case studies.	PSO2, PSO4		
	CO 6. Apply principles of environmental impact assessment and ecological economics for planning, policy, and resource valuation.	PSO2, PSO4		
Content:		No of hours	Mapped to CO	Cognitive Level
Module 1:	<p>Module 1: Population and Spatial Ecology</p> <p>1.1 Life History Traits and Population Dynamics Life history traits, r/K selection, reproductive trade-offs, semelparity, iteroparity, survivorship curves (Type I–III), exponential and logistic growth, carrying capacity, population regulation (density-dependent and density-independent), dispersion patterns, species-area relationship, population cycles.</p> <p>1.2 Population Structure and Diversity Assessment Frequency, density, abundance, species richness, evenness, Simpson’s Index, Shannon-Wiener Index, quadrat and transect methods, rarefaction, alpha-beta-gamma diversity.</p>	15	CO1, CO2, CO3	K1, K2, K3, K4

	<p>1.3 Spatial Ecology and Metapopulations Metapopulation concepts, Levins model, source-sink dynamics, habitat fragmentation, patch occupancy, local extinction, metapopulation conservation, spatial heterogeneity.</p> <p>1.4 Community Assembly and Coexistence Mechanisms Niche theory, neutral theory, metacommunity dynamics, intermediate disturbance hypothesis (IDH), storage effect, niche vs neutral models, species coexistence.</p> <p>1.5 Species Distribution Modelling (SDM) Environmental niche modelling (ENM), MaxEnt basics, GIS-based tools, ENM applications in ecology and conservation.</p>			
Module 2:	<p>Module 2: Interactions, Evolution and Molecular Ecology</p> <p>2.1 Ecological Interactions and Community Networks Mutualism, parasitism, predation, competition, commensalism, amensalism; exotic, invasive, native species; predator-prey models (Lotka-Volterra, Rosenzweig-MacArthur), functional responses (Type I–III), optimal foraging theory, keystone species, facilitation, trophic cascades, ecological networks (connectance, nestedness, modularity).</p> <p>2.2 Molecular and Evolutionary Ecology Genetic diversity in populations, gene flow, migration, effective population size, population structure (F-statistics), bottlenecks, founder effects, metapopulation genetics, landscape genetics, phylogeography.</p> <p>2.3 Genomics and Conservation Genetics Molecular markers (SSR, AFLP, RAPD), barcoding, adaptive radiation, molecular ecology of GMOs, conservation genetics, rapid evolution and ecological consequences, community phylogenetics, phylogenetic niche conservatism.</p>	15	CO1, CO3, CO4	K1, K2, K3, K4, K5
Module 3:	<p>Module 3: Applied Ecology, EIA and Ecological Economics</p> <p>3.1 Conservation Biology and Global Change Climate change biology, global environmental change, IPCC, SDGs, COP</p>	15	CO5, CO6	K3, K4, K5, K6

	<p>summits, REDD+, Kyoto Protocol; UNESCO biosphere reserves, biodiversity loss and drivers, in-situ and ex-situ conservation, ecological restoration, carbon sequestration, ecosystem-based adaptation (EbA), protected area networks, participatory and traditional ecological knowledge, National Biodiversity Authority, WCMC, CITES, Indian case studies (e.g., Western Ghats, Silent Valley).</p> <p>3.2 Environmental Impact Assessment (EIA) History and objectives of EIA, EIA Notification 2006, Environmental Impact Statement (EIS), Environmental Management Plan (EMP), projects requiring EIA in India, screening, scoping, baseline data collection, impact prediction (checklist, matrix, network, overlay, Leopold matrix), biological impact assessment, carrying capacity analysis, public consultation process, field data integration, Indian case studies, MoEF&CC guidelines.</p> <p>3.3 Ecological Economics and Environmental Valuation Ecological economics, polluter-pays principle, GNP vs green GDP, natural resource accounting (NRA), valuation of ecosystem services (provisioning, regulating, supporting, cultural), methods (contingent valuation, travel cost, cost-benefit analysis), carbon credits, environmental auditing, role of EE in national planning.</p>			
Pedagogy:	Lectures, Assignments, Mini Projects, Field Visits, Group Discussion			
Text Books:	<ol style="list-style-type: none"> Ambasht R.S. & Ambasht N.K. (2023). A Textbook of Plant Ecology (16th Edition), CBS Publishers & distributors Pvt. Ltd., India. Canter L (1996) Environmental Impact Assessment, 2nd Edition, McGraw Hill Publishing Company. Odum, E. P. (2007) Fundamentals of Ecology, 5th edition, Thomson books. Sundara S. R. (2003) Practical Manual of Plant Ecology and Plant Physiology, Anmol Publisher, India. Tiwari S.C. (2005) Concepts of Modern Ecology. 1st Edition. M/s Bishen Singh Mahendra Pal Singh Publishers, India. 			
References/	<ol style="list-style-type: none"> Alan, B. (1993). Applying Ecology. Chapman & Hall 			

<p>Readings:</p>	<ol style="list-style-type: none"> 2. Arjun K.A. Rathi (2023) Anatomy of the Indian Environmental Impact Assessment Practice - Learnings for the EIA Professionals and Policymakers. White Falcon Publishing, India. 3. Beebee, T.J.C. and Graham, R. (2004). An Introduction to Molecular Ecology. Oxford University Press. 4. Begon, M., Townsend, C. R. and Harper, J. L. (2005). Ecology: From individuals to Ecosystems 4th edition, Wiley-Blackwell. 5. Cain, Michael L., Bowman, William D and Hacker, Sally D (2008). Ecology. Sinauer Associates, Inc. 6. Freeland, J.R., Heather, K. and Petersen, S. (2011). Molecular Ecology (Second Edition). John Wiley & Sons, Ltd. 7. Graham R., Michael, S. and Trevor, B. (2017). An Introduction to Molecular Ecology (Third Edition). Oxford University Press. 8. Jain, S. V. (2021). Applied Ecology and Sustainable Environment. BFC Publications. 9. Michael, B., Martin, M. and Thompson, D.J. (2009). Population Ecology- A unified study of Animals and Plants. Blackwell Science. 10. Mittelbach, G.G. (2012). Community Ecology. Sinauer Associates, Inc. 11. Nunes, P. A., Van Den Bergh, J. C., & Nijkamp, P. (2003). The ecological economics of biodiversity: methods and policy applications. Edward Elgar Publishing Ltd. 12. Prasad, K. V. (2022) 'Ecosystem Ecology'. In Insect Ecology: Concepts to Management, Springer, Singapore, 2022. 13. Yadav, P. R., and Mishra, S. R. (2004) Environmental biology, Discovery publication, New Delhi.
<p>Web Resources:</p>	<ol style="list-style-type: none"> 1. https://www.nemi.gov/home/ 2. https://www.biodiversitylibrary.org/ 3. https://eol.org/ 4. https://www.ipcc.ch/ 5. https://hero.epa.gov/hero/index.cfm/search/index 6. https://moef.gov.in/ 7. https://www.indiaenvironmentportal.org.in/ 8. https://cpcb.nic.in/

Title of the Course	Lab in Plant Ecology and Environment
Course Code	BOT-5206
Number of Credits	1
Theory/Practical	Practical
Level	400
Effective from AY	2025-26
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Corresponding theory course (BOT-5205)	
Course Objectives:	<ul style="list-style-type: none"> ● Introduce practical tools and field methods in population and community ecology. ● Develop skills in assessing biodiversity, species diversity, and vegetation structure. ● Train students in the application of ecological models, molecular data, and statistical tools. ● Introduce students to ecological software and GIS tools used in species distribution and impact assessments. ● Enable interpretation of ecological data for conservation, management, and decision-making. 	
Course Outcomes:		Mapped to PSO
	CO 1. Apply field methods to quantify plant population and community characteristics.	PSO1
	CO 2. Compute diversity indices and interpret species distribution and community structure.	PSO1, PSO2

	CO 3. Evaluate the ecological impact of natural or anthropogenic changes using biological and environmental assessment techniques.		PSO2, PSO3	
	CO 4. Analyze genetic diversity using molecular marker data and visualize phylogenetic patterns.		PSO3	
	CO 5. Apply ecological modelling and spatial analysis tools to predict species distribution and assess biodiversity patterns for ecological predictions and biodiversity modelling.		PSO3	
	CO 6. Interpret ecological roles of keystone or indicator species for conservation prioritization.		PSO1, PSO2, PSO4	
Content:		No of hours	Mapped to CO	Cognitive Level
Module 1:	1. Study the population structure of a local plant community using quadrat sampling to determine density, frequency, abundance, and calculate the Importance Value Index (IVI).	2	CO1, CO2	K1, K3, K4
	2. Calculate species diversity of plant communities using Shannon-Wiener and Simpson's diversity indices from field or provided datasets.	2	CO2	K1, K3, K4
	3. Assess dispersion patterns of plant species and interpret species-area relationships using quadrat-based sampling.	2	CO1, CO2	K3, K4
	4. Compare community composition using similarity and dissimilarity indices such as Jaccard's and Sorensen's coefficient.	2	CO2	K1, K4
	5. Observe and document the stratification and physiognomy of local vegetation to understand vertical structure and plant form.	2	CO1	K2, K3
	6. Evaluate the trophic status of an aquatic habitat through algal count or chlorophyll content estimation.	4	CO1, CO3	K4, K5

	7. Study the effect of industrial or domestic effluents on plant growth under controlled laboratory conditions.	2	CO3	K4, K5
	8. Analyze molecular marker data (e.g., SSR or RAPD profiles provided) to estimate genetic diversity and infer gene flow or population differentiation (F-statistics).	2	CO4	K4, K5
	9. Perform a basic phylogenetic tree visualization using online tools (e.g., iTOL) to understand community phylogenetics.	2	CO4	K2, K4
	10. Use the MaxEnt software (demo-based) to model and predict species distribution based on environmental and occurrence data.	2	CO5	K3, K6
	11. Conduct a rapid Environmental Impact Assessment (EIA) for a hypothetical or real-life project using the Leopold Interaction Matrix.	2	CO3, CO5	K3, K4, K5, K6
	12. Apply GIS tools (e.g., Google Earth Pro or QGIS demo) to map vegetation types and analyze land use patterns or habitat fragmentation.	2	CO5	K3, K4
	13. Assess biodiversity in a forest or park through field visits by recording species richness, disturbance levels, and regeneration status.	2	CO1, CO6	K3, K4, K5
	14. Identify and report the ecological role of a local keystone, flagship, or indicator species through secondary data or local observation.	2	CO1, CO6	K2, K5
Pedagogy:	Hands-on, Lab and field based experiments, Demonstrations, Group Discussion, Mini projects.			
Text Books:	<ol style="list-style-type: none"> Ambasht R.S. & Ambasht N.K. (2023). A Textbook of Plant Ecology (16th Edition), CBS Publishers & distributors Pvt. Ltd., India. Canter L (1996) Environmental Impact Assessment, 2nd Edition, McGraw Hill Publishing Company. Odum, E. P. (2007) Fundamentals of Ecology, 5th edition, Thomson books. Sundara S. R. (2003) Practical Manual of Plant Ecology and Plant Physiology, Anmol Publisher, India. Tiwari S.C. (2005) Concepts of Modern Ecology. 1st Edition. M/s Bishen Singh Mahendra Pal Singh Publishers, 			

	India.
References/ Readings:	<ol style="list-style-type: none"> 1. Alan, B. (1993). Applying Ecology. Chapman & Hall 2. Arjun K.A. Rathi (2023) Anatomy of the Indian Environmental Impact Assessment Practice - Learnings for the EIA Professionals and Policymakers. White Falcon Publishing, India. 3. Beebee, T.J.C. and Graham, R. (2004). An Introduction to Molecular Ecology. Oxford University Press. 4. Begon, M., Townsend, C. R. and Harper, J. L. (2005). Ecology: From individuals to Ecosystems 4th edition, Wiley-Blackwell. 5. Cain, Michael L., Bowman, William D and Hacker, Sally D (2008). Ecology. Sinauer Associates, Inc. 6. Freeland, J.R., Heather, K. and Petersen, S. (2011). Molecular Ecology (Second Edition). John Wiley & Sons, Ltd. 7. Graham R., Michael, S. and Trevor, B. (2017). An Introduction to Molecular Ecology (Third Edition). Oxford University Press. 8. Jain, S. V. (2021). Applied Ecology and Sustainable Environment. BFC Publications. 9. Michael, B., Martin, M. and Thompson, D.J. (2009). Population Ecology- A unified study of Animals and Plants. Blackwell Science. 10. Mittelbach, G.G. (2012). Community Ecology. Sinauer Associates, Inc. 11. Nunes, P. A., Van Den Bergh, J. C., & Nijkamp, P. (2003). The ecological economics of biodiversity: methods and policy applications. Edward Elgar Publishing Ltd.
Web Resources:	<ol style="list-style-type: none"> 1. https://www.nemi.gov/home/ 2. https://www.biodiversitylibrary.org/ 3. https://eol.org/ 4. https://www.ipcc.ch/ 5. https://hero.epa.gov/hero/index.cfm/search/index 6. https://moef.gov.in/ 7. https://www.indiaenvironmentportal.org.in/ 8. https://cpcb.nic.in/

Title of the Course	Applied Plant Histochemistry
Course Code	BOT-5207
Number of Credits	3
Theory/Practical	Theory
Level	400
Effective from AY	2025-26
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	<ul style="list-style-type: none"> • Understand the structural and organizational complexity of plant tissues, cells, and associated microorganisms. • Develop skills in tissue fixation, sectioning, staining, and advanced microscopic techniques. • Interpret histochemical and cytochemical localization of primary and secondary plant biomolecules. • Apply modern microscopy and imaging tools for plant tissue analysis. • Evaluate the relevance of histochemical techniques in applied plant sciences, including diagnostics, biotechnology, and environmental studies. 	
Course Outcomes:	Students will be able to:	Mapped to PSO
	CO 1. Describe the structural organization of plant cells, tissues, and microorganisms relevant to histological studies.	PSO1

	CO 2. Explain the chemistry, techniques, and theoretical principles involved in fixation, sectioning, and preservation of biological materials.		PSO1, PSO3	
	CO 3. Compare different microscopy techniques and explain their principles, instrumentation, and applications in plant tissue imaging and analysis.		PSO1, PSO3	
	CO 4. Apply the principles and protocols of cyto-, histo-, enzyme-, and immunohistochemistry for localization of primary and secondary metabolites in plants.		PSO1, PSO4	
	CO 5. Evaluate the diagnostic and analytical significance of histochemical techniques in developmental biology, stress physiology, pathology, and biotechnology.		PSO2, PSO4	
	CO 6. Discuss recent innovations in histochemistry including advanced imaging techniques, biosensors, and integration with digital tools for plant diagnosis.		PSO3, PSO4	
Content:		No of hours	Mapped to CO	Cognitive Level
Module 1:	<p>Fundamentals of Plant Histology and Tissue Preparation</p> <p>1.1 Introduction to plant histology: Structure and organization of plant cells, tissues, and associated microorganisms</p> <p>1.2 Chemistry and practice of fixation: Types of fixatives and their biological relevance</p> <p>1.3 Techniques of sectioning: Whole mounts, hand sections, microtomy, cryo- and ultra-microtomy</p> <p>1.4 Freeze-drying and preservation of biological specimens</p> <p>1.5 Safety protocols and good histological practices</p>	10	CO 1, CO 2	K1, K2, K3
Module 2:	<p>Microscopy Techniques and Image Analysis</p> <p>2.1 Light-matter interaction and its significance in microscopy</p> <p>2.2 Kohler illumination and contrast-enhancement techniques</p>	12	CO3, CO6	K2, K3, K4

	<p>2.3 Principles, instrumentation, and applications of: Bright-field microscopy; Phase-contrast and dark-field microscopy; Polarization microscopy; Fluorescence microscopy; Confocal laser scanning microscopy (CLSM)</p> <p>2.4 Introduction to live-cell imaging and 3D tissue visualization</p> <p>2.5 Photomicrography: Basic techniques of image capturing; Conventional and digital photography; Principles of cameras, lenses, resolution, depth of field, lighting; Record-keeping and storage of photomicrographs</p> <p>2.6 Introduction to image analysis tools: Calibration and morphometric measurements; Overview of commonly used software (e.g., ImageJ/Fiji)</p>			
Module 3:	<p>Histochemical and Cytochemical Localization of Biomolecules</p> <p>3.1 Cyto- and histo-chemistry using bright-field microscopy:</p> <p>3.1.1 Single and double staining techniques</p> <p>3.1.2 Localization of carbohydrates, proteins, lipids, and nucleic acids</p> <p>3.1.3 Detection of phenolic compounds, lignins, cutins, suberin, waxes</p> <p>3.1.4 Mineral detection: Calcium, potassium, iron, and other trace elements</p> <p>3.2 Study of cell walls, starch grains, crystals, and other anisotropic materials using bright-field and polarisation microscopy; Applications of studying cell membranes, protoplasts, and infected tissues</p> <p>3.3 Autofluorescence and use of fluorochromes; Localization of proteins, lysine-rich proteins, nucleic acids, phytins; Use of FITC-bound dextrans and tissue-specific fluorochromes using fluorescent and bright-field microscopy.</p> <p>3.4 Enzyme histochemistry: Localization of esterases, phosphatases, peroxidases, and other enzymes</p> <p>3.5 Immunohistochemistry: Principle, antibody tagging, visualization, and relevance in plant sciences</p>	12	CO4, CO5, CO6	K2, K3, K4, K5
Module 4:	<p>Module 4: Advanced Techniques and Applications in Histochemistry</p> <p>4.1 Electron microscopy:</p> <p>4.1.1 Principles and instrumentation of SEM and TEM</p>	11	CO5, CO6	K1, K2, K3, K4, K5, K6

	<p>4.1.2 Specimen preparation, ultrathin sectioning, and contrast staining.</p> <p>4.2 Histochemical localization of secondary metabolites: Alkaloids, terpenoids, flavonoids, and other bioactive compounds.</p> <p>4.3 Applications in: Medicinal plant diagnostics and pharmacognosy; Tissue differentiation and developmental biology; Environmental stress detection and pathogen interactions; Biotechnological innovations and nano-histochemistry</p> <p>4.4 Recent advances of histochemistry: Fluorescent biosensors and nano-tagging; AI-based tissue image analysis; Integration with omics and systems biology for diagnostics</p>			
Pedagogy:	Lectures, Assignments, Seminars, Case Study Discussion, Group Discussion, Mini Projects.			
Text Books:	<ol style="list-style-type: none"> Chakraborty M. (2012). Histology and Histochemistry, Wisdom Press, New Delhi. Chakraborty M. (2012). Histology and Histochemistry, Wisdom Press, New Delhi. Conn. H.J. (1977). Biological Stains. R. D. Lillie (Ed.) The Williams and Wilkins Co., Reprinted by Sigma Chemical Company, U.S.A. Hayat, M.A. (1986). Basic Techniques for Transmission Electron Microscopy. Academic Press. London and New York. Jensen, W.A. (1962). Botanical Histochemistry Principles and Practice. W. H. Freeman and Company, San Francisco, U.S.A. Krishnamurthy, K.V. (1988). Methods in Plant Histochemistry. S. Viswanthan (Printers & Publishers) Pvt. Ltd., Chennai. Lacey, A. J. (1989). Light microscopy in biology a practical approach, IRL Press, Oxford University, U.K. Pears, A.G.E. (1980). Histochemistry Theoretical and Applied, Preparative and Optical Techniques. Vol. I. Fourth Edition. Churchill Livingstone. London and New York. 			
References/ Readings:	<ol style="list-style-type: none"> Badria, F. A., & Aboelmaaty, W. S. (2019). Plant Histochemistry: A versatile and indispensable tool in localization of gene expression, enzymes, cytokines, secondary metabolites and detection of plants infection and pollution. <i>Acta Scientific Pharmaceutical Sciences</i>, 3(7), 88-100. David L. Spector and Robert D. Goldman. (2006). Basic methods in microscopy, Cold Spring Harbor Laboratory Press, Cold Spring Harbor, New York. 			

3. **Demarco, D.** (2017). Histochemical analysis of plant secretory structures. In *Histochemistry of single molecules* (pp. 313-330). Humana Press, New York, NY.
4. **Dibal, N. I., Garba, S. H., & Jacks, T. W.** (2022). Histological stains and their application in teaching and research. *Asian Journal of Health Sciences*, 8(2), ID43-ID43.
5. **Gartner, L.P. and Hiatt, J.L.** (2006). *Color Textbook of Histology e-book*. Elsevier Health Sciences.
6. **Golberg, M., Kobos, J., Clarke, E., Bajaka, A., Smędra, A., Balawender, K., ... & Żytkowski, A.** (2024). Application of histochemical stains in anatomical research: A brief overview of the methods. *Translational Research in Anatomy*, 100294.
7. **Javaeed, A., Qamar, S., Ali, S., Mustafa, M. A. T., Nusrat, A., & Ghauri, S. K.** (2021). Histological stains in the past, present, and future. *Cureus*, 13(10).
8. **Kiernan J.A.** (2015). *Histological and Histochemical Methods: Theory and Practice* (5th edition), Scion Publishing Ltd., U.K.
9. **Shyamasundari, K. and K. Rao H.** (2007). *Histochemistry in focus. A Sourcebook of techniques and research needs*, M.J.P. Publishers, Chennai.
10. **William A. Jensen.** (2015) *Botanical Histochemistry: Principles and Practice*. Agri Horti Press, India
11. **Yadav, V., Arif, N., Singh, V. P., Guerriero, G., Berni, R., Shinde, S., ... & Tripathi, D. K.** (2021). Histochemical techniques in plant science: More than meets the eye. *Plant and Cell Physiology*, 62(10), 1509-1527
12. **Zhou, J. and Xi'an J.** (2017). *Histochemistry*, University Press Co. Germany: De Gruyter.

Title of the Course	Lab in Applied Plant Histochemistry
Course Code	BOT-5208
Number of Credits	1
Theory/Practical	Practical
Level	400
Effective from AY	2025-26
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Corresponding theory course (BOT-5207)	
Course Objectives:	<ul style="list-style-type: none"> • To provide hands-on experience in histochemical and cytochemical staining techniques for localization of biomolecules in plant tissues. • Train students in advanced microscopy techniques including bright-field, fluorescence, polarization, and electron microscopy. • Develop skills in photomicrography, image capture, and digital image analysis relevant to plant histochemistry. • Understand the practical applications of histochemical methods in diagnosing plant physiology, pathology, and environmental interactions. • Impart knowledge on natural dye extraction and evaluation for biological staining. • Foster critical observation and analytical skills through microscopic examination of plant anatomical and biochemical features. 	
Course Outcomes:	Students will be able to:	Mapped to PSO

	CO 1. Demonstrate histochemical staining techniques for localization of proteins, lipids, starch, and secondary metabolites in plant tissues.		PSO1, PSO3	
	CO 2. Apply and interpret results from various microscopy techniques including bright-field, fluorescence, polarization, and SEM.		PSO3, PSO4	
	CO 3. Analyze plant tissue structures using digital image analysis software for measuring and annotating histological features.		PSO3	
	CO 4. Apply histochemical and microscopy techniques to analyze structural and physiological variations in plant tissues.		PSO1, PSO2	
	CO 5. Evaluate natural plant dyes for their efficacy as biological stains compared to synthetic dyes.		PSO4	
	CO 6. Develop observational and analytical skills essential for scientific research in plant histochemistry and imaging.		PSO3, PSO 4	
Content:		No of hours	Mapped to CO	Cognitive Level
Module 1:	1. Study of natural auto-fluorescence in plant tissues using U.V., violet, blue, and green excitation filters under fluorescence microscopy.	2	CO1, CO2	K2, K3
	2. Localization of proteins in plant tissues using both non-fluorescent stains (e.g., Coomassie Brilliant Blue, Ninhydrin, Aniline Blue) and fluorochrome-conjugated dyes (e.g., FITC-tagged dextrans).	4	CO1, CO6	K2, K3, K4
	3. Localization of lipids in plant tissues using traditional dyes (e.g., Sudan Black, Sudan III) and fluorescence-based probes (e.g., Nile Red).	2	CO1, CO6	K2, K3, K4
	4. Localization of starch using iodine-potassium iodide (I2KI); comparison of cytoplasmic vs. plastidial localization in various plant tissues.	2	CO1, CO6	K2, K3, K4
	5. Visualization of anisotropic materials (e.g., starch grains, calcium oxalate	2	CO1,	K2, K3

	crystals, stomata) using polarization microscopy.		CO2	
6.	Comparative imaging of healthy and pathogen-infected plant tissues using bright-field and fluorescence microscopy to assess structural and physiological changes.	2	CO4	K4, K5
7.	To identify and study the distribution, types, and morphology of calcium oxalate crystals (e.g., raphides, druses, styloids) in various plant tissues using bright-field microscopy.	2	CO1, CO2	K2, K3
8.	To observe plasmodesmata structures in the cell walls of plant tissues using staining techniques (e.g., aniline blue or callose staining).	2	CO1, CO2	K2, K3
9.	Study of Protein Bodies and Storage Organelles Using Naphthol Blue Black Staining	2	CO1, CO2	K2, K3
10.	Photomicrography: Hands-on practice of image capture using bright-field, dark-field, polarization, and fluorescence microscopy; focus on resolution, exposure, and scale calibration.	2	CO3	K3, K4
11.	Digital image analysis using open-source software (e.g., ImageJ/Fiji): Introduction to calibration, morphometric measurements, and annotation of micrographs.	2	CO3	K3, K4
12.	Demonstration of Scanning Electron Microscopy (SEM): Instrumentation, sample preparation, and interpretation of SEM micrographs (demo/video-based if instrument not locally available).	2	CO2	K2
13.	Extraction of natural plant-derived dyes from colored plant tissues (e.g., beetroot, turmeric, spinach, hibiscus petals).	2	CO5	K3, K4
14.	Evaluation of natural dyes as biological stains: Testing specificity and contrast in histological sections; comparing with synthetic dyes.	2	CO5, CO6	K4, K5

Pedagogy:	Hands-on, Demonstrations, Group Discussion
Text Books:	<ol style="list-style-type: none"> 1. Chakraborty M. (2012). Histology and Histochemistry, Wisdom Press, New Delhi. 2. Chakraborty M. (2012). Histology and Histochemistry, Wisdom Press, New Delhi. 3. Conn. H.J. (1977). Biological Stains. R. D. Lillie (Ed.) The Williams and Wilkins Co., Reprinted by Sigma Chemical Company, U.S.A. 4. Hayat, M.A. (1986). Basic Techniques for Transmission Electron Microscopy. Academic Press. London and New York. 5. Jensen, W.A. (1962). Botanical Histochemistry Principles and Practice. W. H. Freeman and Company, San Francisco, U.S.A. 6. Krishnamurthy, K.V. (1988). Methods in Plant Histochemistry. S. Viswanthan (Printers & Publishers) Pvt. Ltd., Chennai. 7. Lacey, A. J. (1989). Light microscopy in biology a practical approach, IRL Press, Oxford University, U.K. 8. Pears, A.G.E. (1980). Histochemistry Theoretical and Applied, Preparative and Optical Techniques. Vol. I. Fourth Edition. Churchill Livingstone. London and New York.
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