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ताळगांव पठार,
गोंय - ४०३ २०६
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(Accredited by NAAC with Grade A+)

GU/Acad –PG/BoS -NEP/2025-26/48 Date: 22.04.2026

CIRCULAR

Ref. No.: GU/Acad –PG/BoS -NEP/2025-26/240 dated 09.07.2025

In supersession to the above referred Circular, the syllabus of Semester III & IV of the **Master of Science in Botany** Programme approved by the Standing Committee of the Academic Council in its meeting held 24th & 25th November 2025, is attached.

The syllabus of Semester I & II approved earlier by the Standing Committee of the Academic Council in its meeting held on 24th & 25th June 2025, is also 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 Digitally signed by ASHWIN V LAWANDE Date: 2026.04.22 17:13:25 +05'30'

(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:

3. Chairperson, BoS in Botany, Goa University.
4. Programme Director, M.Sc. Botany, Goa University.
5. Controller of Examinations, Goa University.
6. Assistant Registrar Examinations (PG), Goa University.
7. 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. (K1, K2)
PSO 2.	Interpret and evaluate plant-environment interactions, including physiological, ecological, and molecular responses to biotic and abiotic factors. (K3, K4, K5)
PSO 3.	Design, conduct, and analyse laboratory experiments in diverse branches of Botany using appropriate scientific tools, techniques, and data interpretation methods. (K3, K4, K5)
PSO 4.	Demonstrate an understanding of sustainable resource utilization, evaluate the potential for bioprospecting, and develop skills for plant-based innovation and bio-entrepreneurship (K4, K5, K6)

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**	

SEMESTER III				
Research Specific Elective (RSE) Courses (12 credits)				
Sr. No.	**Course Code**	**Title of the Course**	**Credits**	**Level**
1	**BOT-6000**	Research Methodology	4	500
2	**BOT-6001**	Pharmacognosy and Phytochemistry	3	500
3	**BOT-6002**	Lab in Pharmacognosy and Phytochemistry	1	500
4	**BOT-6003**	Genome Informatics	3	500
5	**BOT-6004**	Lab in Genome Informatics	1	500
6	**BOT-6005**	Plant Omics	4	500
7	**BOT-6006**	Mycorrhizal Biotechnology	3	500
8	**BOT-6007**	Lab in Mycorrhizal Biotechnology	1	500
9	**BOT-6008**	Algal Biotechnology	3	500
10	**BOT-6009**	Lab in Algal Biotechnology	1	500
11	**BOT-6010**	Plant Stress Physiology	4	500
12	**BOT-6011**	Plant Eco-physiology and Wetland Biotic Interactions	4	500
Total Credits for RSE Courses in Semester III			**12**	
Discipline Specific Vocational Elective (DSVE) Courses (8 credits)				
Sr. No.	**Course Code**	**Title of the Course**	**Credits**	**Level**
1	**BOT-6401**	Ecotourism	1T+2P	500
2	**BOT-6402**	Mushroom Biotechnology	1T+1P	500
3	**BOT-6403**	Oenology (Wine Science and Technology)	1T+1P	500
4	**BOT-6404**	Agro-Technology	1T+1P	500
5	**BOT-6405**	Eco-Crafts and Sustainable Lifestyle Products	1T+1P	500
Total Credits for DSVE Courses in Semester III			**8**	
Total Credits in Semester III			**20**	

Discipline Specific Dissertation (DSD) (40 Credit Dissertation)				
Sr. No.	**Course Code**	**Title of the Course**	**Credits**	**Level**
1	**BOT-6501**	Discipline Specific Dissertation	**40****	**500**

**Along with 4C of research methodology course + 4C of subject specific courses from RSE

SEMESTER IV				
Generic Elective (GE) Courses (20 credits)				
Sr. No.	**Course Code**	**Title of the Course**	**Credits**	**Level**
1	**BOT-6201**	Seed Science and Technology	4	500
2	**BOT-6202**	Post-harvest Technology for Fruit Crops	2	500
3	**BOT-6203**	Ethnobotany	2	500
4	**BOT-6204**	Sustainable Agriculture	2	500
5	**BOT-6205**	Aquatic Plant Resources and its Conservation	2	500
6	**BOT-6206**	Soil Science	2	500
7	**BOT-6207**	Ancient Treatises on Plant Science and Practices	2	500
8	**BOT-6208**	Plant-Animal Interactions	4	500
9	**BOT-6209**	Bioremediation	2	500
Total Credits for GE Courses in Semester IV			**20**	

Discipline Specific Dissertation (DSD) (20 Credit Dissertation)				
Sr. No.	**Course Code**	**Title of the Course**	**Credits**	**Level**
1	**BOT-6502**	Discipline Specific Dissertation	**20***	**500**

*Along with 4C of research methodology course

Blooms Taxonomy Cognitive Levels	
Cognitive Level	**Notations**
K1	Remembering
K2	Understanding
K3	Applying
K4	Analyzing
K5	Evaluating
K6	Create

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:	• 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, pteridophytes, and gymnosperms.		PSO1	
	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:	**1.1. Introduction to Botany:** Introduction to plant kingdom; **S**cope of Botany; Importance and applications of botany in agriculture, medicine, and environment; Relation of plants to man. **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. **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. **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. **1.5. Plant Morphology:** Morphology of root, stem, leaf, flower, fruit, and seed; Types of inflorescences; Modifications of roots, stems, and leaves.	**15**	CO1, CO2	K1, K2
Module 2:	**2.1 Plant Ecology:** Ecosystem: Components and energy flow; Plant adaptations: Hydrophytes, xerophytes, halophytes; Ecological succession; Biodiversity and conservation.	**15**	CO3, CO4	K1, K2

	2.2 Plant Reproduction: Asexual and sexual reproduction; Structure of flower: Microsporogenesis and Megasporogenesis; Pollination and fertilization; Seed development and dispersal. **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). **2.4 Genetics:** Mendel's laws of inheritance; Monohybrid and dihybrid crosses; Chromosomes and gene concept. **2.5 Economic Botany:** Useful and harmful plants; Medicinal plants, food plants (cereals, pulses), oils, fibers, timber plants.			
Pedagogy:	Lectures/ Use of Multimedia / Assignments/ Demonstrations			
Text Books:	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:	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:	1. https://archive.org/details/textbookofgenera029793mbp 2. https://archive.org/details/fundamentalsofbo0000unse_z7a4 3. https://dokumen.pub/fundamentals-of-botany-1-9780070681767-0070681767.html 4. https://herba.msu.ru/shipunov/school/biol_154/textbook/intro_botany.pdf 5. https://www.researchgate.net/publication/387541607_Fundamentals_of_Botany

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Title of the Course	Basics 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:	● 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 Company. 4. **Satyanarayana, U., & Chakrapani, U**. (2017). Biochemistry (5th ed.). Elsevier India. 5. **Voet, D., Voet, J. G., & Pratt, C. W.** (2016). Fundamentals of Biochemistry: Life at the Molecular Level (5th ed.). Wiley.
References/ Readings:	1. **Koshland, D. E.** (2002). The seven pillars of life. Science, 295(5563), 2215–2216. https://doi.org/10.1126/science.1068489 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 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
Web Resources:	1. https://www.biochemistry.org/education/ 2. https://bio.libretexts.org/Bookshelves/Biochemistry 3. https://www.ncbi.nlm.nih.gov/books/

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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:	● 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, Pyrrhophyta, 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:** Sphaerocarpales, Calobryales, Takkakiales, Marchantiales, Jungermanniales, **Anthoceotae**: Anthocerotales; **Musci:** Sphagnales, Andaeales, 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, Eqisetophyta 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.			

	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,
References/ Readings:	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.

	16. **Parihar, N.S.** (1976) Biology and Morphology of the Pteridophytes. Central Book Depot. 17. **Parihar, N.S.** (1980) Bryophytes: An introduction to Embryophyta. Vol. I Bryophyta. Central Book Depot. 18. **Prem Puri** (1981) Bryophytes: Morphology, Growth and Differentiation, Atmaram and Sons, New Delhi. 19. **Prescott G. W**. (1969) The algae: A review. Nelson, London. 20. **Rashid, A.** (1999) An Introduction to Pteridophyta, Vikas Publishing House Pvt. Ltd., New Delhi. 21. **Ramanujan, C.K.G.** (1970) Indian Gymnosperms in time and space. Today & Tomorrow's Printers & Publishers. 22. **Sharma, O.P.** (1990) Textbook of Pteridophyta. Macmillan India Ltd., Delhi. 23. **Singh, V. P**. (2006) Gymnosperms (Naked seed plants): Structure and Development, Sarup and Sons, New Delhi.
Web Resources:	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

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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:	• To introduce and aquent 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 Salviniales.	**8**	CO1, CO2, CO3, CO4	K1, K2, K3
	4. Study of vegetative and reproductive features of important Gymnospermopsida 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:	1. **Biswas C. and Johri B.M.** (1997) Gymnosperms. Narosa Publishers, New Delhi. 2. **Bold H.C. and Wynne M.J.** (1985) Introduction to algae; Structure and reproduction. Prentice Hall, Englewood cliffs, New Jersey. 3. **Desikachary, T.V.** (1959) Cyanophyta. ICAR, New Delhi. 4. **Parihar, N.S.** (1976) Biology and Morphology of the Pteridophytes. Central Book Depot. 5. **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:	1. **Bellinger, E.G., & Sigee, 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:	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

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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:	• 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:	**Principles and Foundations of Plant Systematics** **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). **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	**15**	CO1, CO2, CO3	K1, K2, K3, K4

	herbaria, botanical gardens, virtual repositories, and digitization initiatives in taxonomic studies. Standard practices in specimen collection, preservation, and herbarium curation. **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. **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.			
Module 2:	**Analytical Tools in Taxonomy and Molecular Cladistics** **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. **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	**15**	CO4, CO6	K1, K2, K3, K4

	software: PAUP*, MrBayes, MEGA, RAxML, IQ-TREE. Importance of tree rooting and interpreting support values (bootstrap, posterior probabilities). **2.3 Molecular Systematics** 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			
Module 3:	**Module III: Modern Classification Systems and Emerging Trends** **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. **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 (Commelenids)), Order Ceratophyllales, (eudicots ((Superrrosids (Rosids, Fabids, Malvids))) and (Superasterids (asterids (campanulids, lamids))))) **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.	**15**	CO4, CO5, CO6	K2, K4, K5, K6

Pedagogy:	Lectures/Assignments/Seminars/Group Discussions/Case-Based Learning/Mini Projects
Text Books:	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:	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. https://doi.org/10.3390/biology12040570 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.
Web Resources:	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/

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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:	• 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, CO5	K3, K4, 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
	Only 30 hours for any of the above practicals will be conducted depending on availability of plant material.			
Pedagogy:	Hands-on Practicals, Field visits, Group Discussions, Assignments and Mini projects			
Text Books:	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:	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. https://doi.org/10.3390/biology12040570 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.
Web Resources:	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/ 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/search 13. 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:	• 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:	**Plant Anatomy** 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. 1.2 Vascular cambium vs cork cambium, factors controlling their activity; lenticels; abscission; wound healing. 1.3 Ontogeny, phylogeny, evolution, ultra-structure and function of primary and secondary xylem; wood anatomy; bio-deterioration of wood and its prevention. 1.4 Ontogeny, phylogeny, evolution, ultra-structure and function of primary and secondary phloem.	**20**	CO1, CO2, CO3, CO4, CO5, CO6	K1, K2, K3, K4, K5, K6

	1.5 Structural variability in leaves including leaf structures of C_3 and C_4 sub-types, CAM plants; leaf histogenesis; leaf meristems; evolution of leaf forms, heteroblasty. Origin, development and ultra-structure of trichomes and stomata. 1.6 Nodal anatomy: Nodal types, phylogenetic and evolutionary considerations. 1.7 Anatomy of monocotyledonous and dicotyledonous seeds and fruits - their ontogeny, structure and functions			
Module 2:	**Embryology** 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. 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. 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, *in vitro* fertilization. 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.	**15**	CO1, CO2, CO3, CO4, CO5	K1, K2, K3, K4, K5
Module 3:	**Palynology** 3.1. Pollen Biology: Pollen morphological characters, Pollen wall features, pollen development and evolution of pollen types, palynology and taxonomy. 3.2. Aeropalynology: Methods of aerospora survey and analysis; pollen allergy and pollen calendars. 3.3. Mellittopalynology: Honey bee and pollen loads; role of apiaries in crop production.	**10**	CO3, CO4, CO5	K1, K2, K3, K4, K5

	3.4. Palaeopalynology: Study of fossil pollens and spores and their significance in paleobotany and coal and oil explorations. 3.5. Pollen biotechnology for crop production and improvement.			
Pedagogy:	Lectures/Assignments/Seminars/Group Discussion			
Text Books:	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:	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.			

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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:	• 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**	CO1, CO2, CO3, CO4, CO5, CO6	K1, K2, K3, K4, K5, K6
	2. Anatomical basis of identification C3 & C4 photosynthetic sub-types in grasses.	**2**		
	3. Phytoliths of grasses and their potential use in identification.	**2**		
	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:	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.

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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:	• 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:	**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. **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. **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.	**15**	CO1, CO4	K1, K2, K3
Module 2:	**2.1 Photosynthesis:** Importance of photosynthesis, Physiological and environmental considerations of photosynthesis. **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), Artificial photosynthesis. Climate change & food and fuel security.	**15**	CO1, CO3, CO4	K1, K2, K3

	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. **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. **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.			
Module 3	**3.1 Phytohormones:** Auxin; Cytokinin; Gibberellins; Ethylene; ABA. Polyamines; Brassinosteroids, Jasmonate, distribution, physiological role and mechanism of action; Hormonal balance concept. **3.2 Photoreceptors:** Phytochromes and their properties, light control, regulatory mechanism; role of phytochrome in phototropism; physiology of flowering and fruiting; Cryptochromes. **3.3 Reactive oxygen species:** ROS generation, its oxidative effect on biomolecules (protein, lipids and DNA); enzymatic and non- enzymatic protective processes, antioxidants. **3.4 Stress Physiology:** Abiotic stresses (drought, salt, temperature and metal), morphological and cellular adaptation; molecular mechanism of stress tolerance and protection. **3.5 Seed dormancy and germination**, senescence, programmed cell death; circadian rhythms in plants (with emphasis on exogenous factors and its mechanism).	**15**	CO1, CO2, CO3, CO4	K1, K2, K3
Pedagogy:	Lectures/ Group discussion/Assignments/Seminars.			
Text Books:	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.
References/ Readings:	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. **Luttuge 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 development. McGraw Hill London. 16. **Thomson Tesar M.B.** (2015) Physiological basis of crop growth and development, Panima.

	17. **Wills R.** (2016) Post-harvest: An introduction to the physiology and handling of fruit.
Web Resources:	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

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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:	• 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:	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. Chapmann 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:	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_Mannual-_BOT-232

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Discipline Specific Elective (DSE) 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. Micropropagation: Techniques of micropropagation, Multiplication by axillary buds, apical shoots and adventitious shoots, Factors affecting micropropagation, Applications and disadvantages of micropropagation. Somaclonal Variation: History, Basis of somaclonal variations, Isolation of somaclonal variants, Factors affecting production of somaclonal variants, Applications and limitations of somaclonal variation.	**12**	CO1, CO2	K1, K2, K3

Module 3:	Germplasm Conservation and Cryopreservation: Modes of conservation, Cryopreservation: Techniques of cryopreservation, cryobank, Pollen bank; Prospects in agricultural and forest biotechnology. 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.	**12**	CO3, CO4	K1, K2, K3
Module 4:	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. Application of Biotechnology in Agriculture, Forestry and human welfare: Marker assisted selection (MAS); Production of Biopesticides; Environmental and Enzyme biotechnology.	**11**	CO5, CO6	K4, K5
Pedagogy:	Lectures/Assignments/Seminars/Group Discussions			
Text Books:	1. Aguilar Cristobel Noe (2008). *Food Science and Food Biotechnology in Developing countries*. Asiatech Publishers Inc. 2. Bhojwani, S. S. and Razdan, M. K. (1997). Plant Tissue Culture: Theory and Practice. Springer Publishers Netherlands. 3. Chawla, H. S. (2024). *Introduction to plant biotechnology* (4th ed.). CBS Publishers and Distributors Pvt. Ltd. 4. Dubey, R. C. (2009). *A text book of Biotechnology.* S. Chand & Co. Ltd. New Delhi. 5. Gautam, H. (2006). *Agricultural & Industrial Applications of Biotechnology.* Rajat Publication. 6. Gupta, N. K., & Gupta, S. (2023). Fundamentals of plant biochemistry and biotechnology. Kalyani Publishers. 7. Harikumar, V.S. (2006). *Advances in Agricultural Biotechnology.* Regency Publishers. 8. Kumar, H.D. (2005). *Agricultural Biotechnology.* Daya Publishing House.			

	9. Prasad (2008). Biotechnology in Sustainable Biodiversity and Food Security. India Book House Limited. 10. Prasad, B. D., Sahni, S., Kumar, P., & Siddiqui, M. W. (2017). *Plant biotechnology, volume 1: Principles, techniques, and applications*. Apple Academic Press, NY. 11. Rajmohan Joshi (2006). Agricultural Biotechnology. Gyan Books. 12. Singh, B. D. (2022). *Plant biotechnology* (4th ed.). MedTech Publishers.
References/ Readings:	1. Bhavneet Kaur, et al. (2008). *Current Topics in Biotechnology.* M.D. Publications, New Delhi. 2. Park, S. (2021). *Plant Tissue Culture: Techniques and Experiments.* Academic Press. 3. Vibha Dhawan (2008). *Biotechnology for Food and Nutritional Security.* Teri Press.

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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:	● 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 hours	Mapped to CO	Cognitive 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 *In vitro* Embryo and Anther culture (*Pisum sativum*, Datura). 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. 9. **Rajmohan Joshi** (2006). Agricultural Biotechnology. Gyan Books. 10. **Park, S.**(2021). Plant Tissue Culture: Techniques and Experiments. Academic Press. 11. **Prasad** (2008). Biotechnology in Sustainable Biodiversity and Food Security. India Book House Limited. 12. **Vibha Dhawan** (2008). Biotechnology for Food and Nutritional Security. Teri Press.
References/ Readings:	1. **Chimdessa, E.** (2020). Composition and preparation of plant tissue culture medium. J. Tissue Cult. Bioeng, 3, 281-286. 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). 3. **Sahoo, L.** (2007). Plant biotechnology lab. manual. transformation, 14, 14. 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.
Web Resources:	1. https://vlab.amrita.edu/index.php?sub=3 2. https://www.ncbi.nlm.nih.gov/books

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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:	● 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 plants.	PSO1
	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:	**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. **1.2 Plant biopolymers:** Cellulose, hemicellulose, xylan and pectin. Biominerals in the plant such as phytoliths and calcium oxalate. **1.**3 **Secondary metabolites**: Physiological roles; Ecological and phylogenetic importance; Main secondary metabolites and their relation with primary metabolites.	**15**	CO1	K1, K2
Module 2:	**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. **2.2 Bioenergetics:** Thermodynamics; exergonic and endergonic reactions; redox potential; biological energy transducers; high-energy compounds; oxidative phosphorylation; ATP structure and its significance. **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.	**15**	CO1, CO4	K1, K2, K3
Module 3:	**3.1 Mechanism of enzyme action:** Introduction to enzymes; Michaelis-Menten equation; mechanism of enzyme action; enzyme kinetics; co-enzymes; Isoenzymes; regulatory	**15**	CO1, CO2,	K1, K2, K3

	enzymes; enzyme inhibition; enzyme regulation; allosteric enzymes, reversible and irreversible covalent modifications of enzymes. **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.		CO3, CO4	
Pedagogy:	Lectures/Assignments/Seminars/Group Discussion			
Text Books:	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:	1. **Berg, Jeremy M** (2012) Biochemistry. WH Freeman and Company, New York. 2. **Bowsher C** (2008) Plant Biochemistry. Garland Science, New York. 3. **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:	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

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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:	• 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 enzyme activity in plant tissues.		PSO1, PSO3	
	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 phosphoglycolipids 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:	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:	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:	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			

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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:	• 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 biotechnological significance.	PSO1

	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:	**Introduction to Plant Microbiology** 1.1 Introduction to plant-microbe interactions: Symbiotic, pathogenic, commensal and opportunistic interactions 1.2 Ecological and evolutionary perspectives of microbial association with plants 1.3 Role of microbes in plant health and stress resilience 1.4 Impact of climate change on plant-microbe interactions 1.5 Introduction to different types of microbes associated with plants: Viruses, Bacteria, Mycoplasma, Fungi, Protozoans, Algae	**9**	CO1	K1, K2, K3
Module 2:	**Plant association with bacteria and viruses** 2.1 Plant Bacteriology: Bacterial diversity and taxonomy, Endophytes, rhizosphere and phyllosphere microbiomes 2.2 Bacteria in biogeochemical cycles Role in nitrogen fixation, phosphate solubilization, metal sequestration, and as biocontrol agents. 2.3 Actinobacteria and actinorhizal symbiosis 2.4 Mycoplasma and L-forms: biology and plant association 2.5 Plant Virology: virus structure, morphology, chemical composition, Nomenclature and classification, Viroids and prions 2.6 Genome organization, replication of viruses, isolation and purification of plant viruses	**12**	CO2, CO3	K2, K3, K4

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

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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:	• 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:	1.1 Preparation of media, understanding of sterilization techniques 1.2 Isolation of phylloplane, rhizosphere, and endophytic microbes. 1.3 Maintenance of pure cultures (phylloplane, rhizosphere, endophytes) using appropriate microbiological media. 1.4 Morphological observation, staining and microscopy of unstained and stained specimens of isolated microbes. 1.5 Biochemical and plant growth promoting assays of plant-associated bacteria. 1.6 Nodulation assay in legumes and observation of Rhizobium-induced nodules	**10**	CO1, CO2	K1, K2, K3
Module 2:	2.1 Isolation (Particle-plating technique and serial dilution) and culturing of Fungi from environmental samples on appropriate media. 2.2 Observation of ecological succession of fungi in various habitats (terrestrial, marine, freshwater). 2.3 Moist chamber method for decomposing substrates (dung, litter). 2.4 Microscopic study of fungal hyphae and reproductive structures. 2.5 Assessment of fungal growth and physiology under different conditions. 2.6 Screening of fungi for enzyme production and antimicrobial activity.	**10**	CO1, CO2, CO3	K1, K2, K3, K4
Module 3:	3.1 Field diagnosis and collection of major plant disease specimens and exploration of databases. 3.2 Tease mounts and hand sections and microscopic examination of fungal pathogens from plant diseased tissues. 3.3 Koch's postulates demonstration using fungal or bacterial pathogen on a model host. 3.4 Mini field-based project: collection, identification, and reporting of major diseases of crop plants from Goa: cereal, vegetable, fruit, plantation crops.	**10**	CO4	K4, K5

Pedagogy:	Hands-on Practicals, Field visits, Assignments and Mini projects
Text Books:	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. **Amaresan, 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. 17. **Prescott, M.J., Harly, J.P. and Klein** Microbilogy 5th (ed.), WCB Mc GrawHill, New York. 18. **Rangaswamy, G. and Mahadevan, A.** (2002). Diseases of Crop Plants in India. Prentice Hall of India, New Delhi.

	19. **Sharma, O.P.** (2007). Text book of Fungi. Tata McGraw Hill, Publishing Co. Ltd. New Delhi.
References/ Readings:	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:	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/

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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:	● 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:	**Classical Genetics and Chromosome Biology** **1.1 Cell Division Basics**: Overview of mitosis, meiosis, cytokinesis, astral microtubules and spindle dynamics; proteolysis in cell cycle. **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. **1.3 Mendelian Principles**: Dominance, segregation, independent assortment; molecular basis of dominance. **1.4 Gene Concept & Extensions**: Alleles, pseudoalleles, multiple alleles, complementation tests, codominance, incomplete dominance, gene interactions, pleiotropy, genomic imprinting, penetrance and expressivity, phenocopy.	**15**	CO 1, CO 2, CO 3	K1, K2, K3, K4

	1.5 Sex Determination and Linkage: Sex-linked, sex-limited, and sex-influenced traits; linkage and crossing over; gene mapping using recombination frequency. **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). **1.7 Structural and Numerical Chromosome Aberrations**: Deletion, duplication, inversion, translocation, aneuploidy, polyploidy and their role in evolution and breeding. **1.8 Recombination and Transposition**: Homologous and non-homologous recombination; transposable elements relevant to plant systems.			
Module 2:	**Molecular Cytogenetics and Developmental Genetics** **2.1 Chromosome Structure and Organization**: Morphology, euchromatin and heterochromatin, centromeres, telomeres, karyotyping, banding techniques; special chromosomes (polytene, lampbrush, B-chromosomes). **2.2 Advanced Regulation of Cell Cycle**: Molecular control of mitosis and meiosis (cyclins, CDKs, checkpoints), cell cycle mutations, mitotic poisons. **2.3 Extranuclear Inheritance**: Chloroplast and mitochondrial DNA, maternal inheritance, biparental and paternal exceptions. **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. **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). **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.	**15**	CO 2, CO 3	K1, K2, K3, K4
Module 3:	**Quantitative Genetics and Plant Breeding** **3.1 Introduction to Plant Breeding**: Objectives, achievements, centers of origin and diversity; domestication and crop evolution; plant introduction and acclimatization.	**15**	CO 4, CO 5, CO 6	K2, K3, K4, K5, K6

	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. **3.3 Breeding Methods and Strategies**: Mass selection, pure line selection, pedigree method, bulk method, backcross method, and recurrent selection; their applications and limitations. **3.4 Distance Hybridization and Breeding Tools**: Barriers to distant hybridization, embryo rescue, somaclonal variation, wide hybridization; *in vitro* techniques (anther, pollen, embryo, and meristem cultures) in breeding programs. **3.5 Genetics and Crossing Techniques of Economically Important Crops**: Wheat, rice, maize, cotton — floral biology, emasculation, pollination control, hybrid seed production. **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. **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.			
Pedagogy:	Lectures, Assignment, Seminars, Group Discussion			
Text Books:	1. **Benjamin Lewin** (2007) Genes IX (9th Edition) Jones and Bartlett Publishers, Inc, USA 2. **Charles A., Janice F., Leland H., Leroy H., Michael G.** (2023) ISE Genetics: From Genes to Genomes (8th Edition), McGraw-Hill Education, US. 3. **James Watson** (2024) Molecular Biology of the GENE new Multi-Colour edition (8th Edition) Affiliated East West Press, India 4. **Hill J., Becker H.C., Tigerstedt P.M.** (1998) Quantitative and Ecological Aspects of Plant Breeding, Springer-Science+Business Media, Germany. 5. **Jain H.K** (2020) Plant Breeding: Mendelian to Molecular Approaches (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) Plant Cytogenetics (2nd Edition), CRC Press, Taylor & Francis, UK			

	8. **Ram J.S.** (2021) Practical Manual on Plant Cytogenetics, CRC Press, Taylor & Francis, UK 9. **Robert J. Brooker** (2017) Genetics: Analysis and Principles 6th Edition, McGraw-Hill Education, US**.** 10. **John E.B.** (2016) Plant Breeding: Past, Present and Future, Springer Nature, New York. 11. **Robert H. Tamarin** (2017) Principles of Genetics (7th Edition), McGraw Hill Education, India 12. **Saidaiah P.** (2022) Advances in Genetics and Plant Breeding (Volume - 17), AkiNik Publications, New Delhi. 13. **Snustad D. Peter, Michael J.S.** (2015) Principles of Genetics (7th edition) John Wiley & Sons Inc., US 14. **Tony H., Sonia G.** (2023). Plant Cytogenetics and Cytogenomics (Methods and Protocols), Humana Press, Springer, USA. 15. **Venkata R.P. Reddy** (2016) Key Notes on Genetics and Plant Breeding, Astral Publishing House, New Delhi.
References/ Readings:	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. *Theoretical and Applied Genetics*, *104*, 751-762. 2. **Broman, K. W., Gatti, D. M., Simecek, P., Furlotte, N. A., Prins, P., Sen, Ś., ... & Churchill, G. A.** (2019). R/qtl2: software for mapping quantitative trait loci with high-dimensional data and multiparent populations. *Genetics*, *211*(2), 495-502. 3. **Bowman, J. L., & Moyroud, E.** (2024). Reflections on the ABC model of flower development. *The Plant Cell*, *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. *Genetics*, *186*(2), 713-724. 5. **Dhingani, R. M., Umrania, 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. **Figueroa, 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.

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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:	● 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, karyotyping, and detection of chromosomal abnormalities.	PSO1

	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 *Allium* cepa 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 *Rheo* sp.	2	CO1, CO2	K2, K4
	4. Study of meiosis in flower buds of *Allium cepa/ Rhoeo discolor*; observation of bivalents, chiasmata, and stages of meiotic division.	4	CO1	K1, K3
	5. Induction of polyploidy using Colchicine in *Trigonella foenum-graecum* / *Vigna* sp.; assessment of phenotypic effects.	4	CO2	K3, K4

	6. Evaluation of mutagenic effects (using EMS/SA/NaOCl/UV/Ethanol stress) on germination, morphology, and seedling traits in *Brassica juncea* / *Oryza sativa*.	4	CO2	K4, K5
	7. Floral biology of *Oryza sativa* and emasculation techniques; identification of floral whorls and pollen/ovule traits.	2	CO4	K2, K4
	8. Floral biology and hybridization techniques in *Zea mays/Saccharum spp.* (Sugarcane); bagging, tagging, and pollen collection.	4	CO4	K2, K3
	9. Demonstration and practice of artificial hybridization techniques in *Oryza sativa* / *Zea mays*.	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
	Only 30 hours of any of the above practicals will be conducted depending on availability of plant materials.			
Pedagogy:	Hands-on Practicals, Group Discussions, Demonstrations, Field visits, Assignments and Mini projects			
Text Books:	1. **Benjamin Lewin** (2007) Genes IX (9th Edition) Jones and Bartlett Publishers, Inc, USA 2. **Charles A., Janice F., Leland H., Leroy H., Michael G.** (2023) ISE Genetics: From Genes to Genomes (8th Edition), McGraw-Hill Education, US.			

	3. **James Watson** (2024) Molecular Biology of the GENE new Multi-Colour edition (8th Edition) Affiliated East West Press, India 4. **Hill J., Becker H.C., Tigerstedt P.M.** (1998) Quantitative and Ecological Aspects of Plant Breeding, Springer-Science+Business Media, Germany. 5. **Jain H.K** (2020) Plant Breeding: Mendelian to Molecular Approaches (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) Plant Cytogenetics (2nd Edition), CRC Press, Taylor & Francis, UK 8. **Ram J.S.** (2021) Practical Manual on Plant Cytogenetics, CRC Press, Taylor & Francis, UK 9. **Robert J. Brooker** (2017) Genetics: Analysis and Principles 6th Edition, McGraw-Hill Education, US**.** 10. **John E.B.** (2016) Plant Breeding: Past, Present and Future, Springer Nature, New York. 11. **Robert H. Tamarin** (2017) Principles of Genetics (7th Edition), McGraw Hill Education, India 12. **Saidaiah P.** (2022) Advances in Genetics and Plant Breeding (Volume - 17), AkiNik Publications, New Delhi. 13. **Snustad D. Peter, Michael J.S.** (2015) Principles of Genetics (7th edition) John Wiley & Sons Inc., US 14. **Tony H., Sonia G.** (2023). Plant Cytogenetics and Cytogenomics (Methods and Protocols), Humana Press, Springer, USA. 15. **Venkata R.P. Reddy** (2016) Key Notes on Genetics and Plant Breeding, Astral Publishing House, New-Delhi.
References/ Readings:	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. *Theoretical and Applied Genetics*, *104*, 751-762. 2. **Broman, K. W., Gatti, D. M., Simecek, P., Furlotte, N. A., Prins, P., Sen, Ś., ... & Churchill, G. A.** (2019). R/qtl2: software for mapping quantitative trait loci with high-dimensional data and multiparent populations. *Genetics*, *211*(2), 495-502. 3. **Bowman, J. L., & Moyroud, E.** (2024). Reflections on the ABC model of flower development. *The Plant Cell*, *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. *Genetics*, *186*(2), 713-724.

	5. **Dhingani, R. M., Umrania, 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. **Figueroa, 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.
Web Resources:	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. *Theoretical and Applied Genetics*, *104*, 751-762. 2. **Broman, K. W., Gatti, D. M., Simecek, P., Furlotte, N. A., Prins, P., Sen, Ś., & Churchill, G. A.** (2019). R/qtl2: software for mapping quantitative trait loci with high-dimensional data and multiparent populations. *Genetics*, *211*(2), 495-502. 3. **Bowman, J. L., & Moyroud, E.** (2024). Reflections on the ABC model of flower development. *The Plant Cell*, *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. *Genetics*, *186*(2), 713-724. 5. **Dhingani, R. M., Umrania, 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. **Figueroa, 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). Pedigree: pedigree database analysis and visualization for breeding and science. *Journal of Heredity*, *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:	● 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:	**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. **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.	**15**	CO1, CO2	K1, K2, K3
Module 2:	**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. **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. **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 interference (RNAi).	**15**	CO1, CO2, CO3	K1, K2, K3
Module 3:	**3.1. Regulation of Gene Expression:** Regulation of gene expression in prokaryotes and Eukaryotes. Expression of lac operon: Lac operon and Tryp operon; Transcriptional	**15**	CO2, CO4	K1, K2, K3

	Control I, Transcriptional Control II, Attenuation, Antitermination, Methylation, alteration of gene expression by DNA sequence rearrangements. **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. **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.			
Pedagogy:	Lectures/Assignments/Seminars/ Group Discussions.			
Text Books:	1. **Benjamin Lewin.** (2008) GENES IX. Jones and Bartlett Publishers, London, UK. 2. **Freifelder D.** (1990) Molecular Biology. Second Edition. Narosa Publishing House, New Delhi. 3. **Old R.W. and Primerose S. B.** (1980) Principles of Gene Manipulation. An Introduction to Genetic Engineering. Blackwell Scientific Publishers. 4. **Tewari, K.K. and Singhal, G.S.** (1997) Plant Molecular Biology and Biotechnology. Narosa Publishing House, New Delhi. 5. **Tropp. B.E.** (2012) Molecular Biology. Fourth Edition. Jones and Bartlett India Pvt. Ltd, New Delhi. 6. **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:	1. **Brown T. A.** (2007) Genomes. Third Edition. Garland Science Publishing, New York. U.S.A. 2. **Coruzzi G.** (1994) Plant Molecular Biology - Genetic Analysis of Plant Development and Metabolism. Springer-Verlag, New York, London 3. **Grierson D and S. Covey.** (1984) Plant Molecular Biology. Panima Educational Agency, New Delhi. 4. **Henry R. J.** (2005) Practical Applications of Plant Molecular Biology. Chapman & Hall, London, UK. 5. **Goldstein E.S., Krebbs 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:	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

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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:	● 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:	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.			

References/ Readings:	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. Wikley 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
Web Resources:	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

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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 aspects of GM crops.		PSO2, PSO4	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	**Foundations of Plant Genetic Engineering and recombinant DNA technology** 1.1 Introduction to genetic engineering and RDT in plant sciences: Applications in agriculture, environment. Conventional breeding vs. genetic engineering. 1.2 Basic principles of DNA manipulation: Restriction-modification systems, DNA modifying enzymes, restriction enzymes, ligation strategies. 1.3 DNA vector structure and properties, Plasmids, Bacteriophages, Cosmids, ssDNA and dsDNA vectors, vector-host systems. 1.4 Genome and cDNA library construction 1.5 Gene cloning techniques, selection strategies for transformants 1.6 Molecular Markers: RFLP, AFLP, RAPD, SSRs for transgene confirmation.	**9**	CO1	K1, K2, K3
Module 2:	**Plant Transformation and Molecular Tools** 2.1 Agrobacterium biology: Ti plasmid, T-DNA, Vir genes, Binary and Co-integrate vectors: detailed mechanisms in Agrobacterium. 2.2 Direct gene transfer methods, Electroporation, biolistics, PEG-mediated transfer and horizontal gene transfer in plants. 2.3 Site-directed mutagenesis: Principles and techniques 2.4 DNA sequencing strategies: Sanger, NGS 2.5 Plant genome organization: Nuclear, mitochondrial, and chloroplast genomes, transcription, translation, retrograde signaling, organelle-specific genetic codes 2.6 Chloroplast transformation: advantages and techniques. 2.7 Gene stacking and multigene engineering for complex traits	**12**	CO1, CO2	K3, K4
Module 3:	**Gene Regulation and Functional Genomics in Plants** 3.1 Gene expression technologies: PCR, RT-PCR, qPCR, microarrays	**12**	CO3, CO4	K4, K5, K6

	3.2 Gene silencing and regulation: Antisense RNA, RNAi Mutants in silencing, VIGS 3.3 Genome editing technologies: TALENs, ZFNs, CRISPR-Cas9 mechanism and applications. 3.4 Promoter Analysis and Enhancer Elements: Plant-specific regulatory elements 3.5 Synthetic Biology Approaches: Design of synthetic gene circuits in plants			
Module 4:	**Applications, Ethics, and Biosafety** 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. 4.2 Genome projects: Rice, maize, wheat. 4.3 Socio-environmental and ethical issues: Public perception and controversies. 4.4 Food safety, labeling, regulatory frameworks, Indian regulatory context: DBT, GEAC, biosafety protocols, Cartagena Protocol on Biosafety. 4.5 Field testing and containment procedures. 4.6 Gene drive technology overview and applications.	**12**	CO4	K4, K5, K6
Pedagogy:	Lectures, interactive discussions, seminar, assignments, Moodle			
Text Books:	1. **Armstrong, C. L., Spencer, T. M., Stephens, M. A., & Brown, S. M.** (2000). Transgenic maize. In L. O'Brien & R. J. Henry (Eds.), Transgenic cereals (pp. 49–70). American Association of Cereal Chemists. 2. **Coruzzi, G., & Puigdomènech, P.** (Eds.). (1994). Plant molecular biology: Genetic analysis of plant development and metabolism (1st ed.). Springer-Verlag. https://doi.org/10.1007/978-3-642-78418-2. 3. **Grumezescu, A. M., & Holban, A. M.** (Eds.). (2017). Genetically engineered foods (Vol. 6). Academic Press. https://doi.org/10.1016/C2015-0-04529-6 4. **Grierson, D., & Covey, S. N.** (1984). Plant molecular biology (1st ed.). Panima Educational Agency. 5. **Freifelder, D.** (1987). Molecular biology (2nd ed.). Narosa Publishing House. 6. **Isaacson, W.** (2022). The code breaker-Young readers edition: Jennifer Doudna and the race to understand our genetic code (1st ed.). Simon & Schuster Books for Young Readers. 7. **Lewin, B.** (1999). Genes VII (7th ed.). Oxford University Press.			

	8. **Lynas, M.** (2018). Seeds of science: Why we got it so wrong on GMOs (1st ed., Vol. 34). Bloomsbury Publishing. 9. **Old, R. W., & Primrose, S. B.** (1980). Principles of gene manipulation: An introduction to genetic engineering (1st ed.). Blackwell Scientific Publications. 10. **Pahara, J., & Legault, J.** (2021). Zero to genetic engineering hero (2nd ed.). Make Community. 11. **Patrick, F.** (2018). Genetic engineering: Emerging concepts and technology (1st ed.). Syrawood Publishing House. 12. **Shaw, C. H.** (Ed.). (1988). Plant molecular biology: A practical approach (1st ed.). IRL Press. 13. **Tewari, K. K., & Singhal, G. S.** (1997). Plant molecular biology and biotechnology (1st ed.). Narosa Publishing House.
References/ Readings:	1. **Barampuram, S., & Zhang, Z. J.** (2023). Plant genetic transformation: Achievements, current status, and future outlook. Frontiers in Plant Science, 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. 3 Biotech, 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. Frontiers in Plant Science, 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. Frontiers in Plant Science, 13, 1045417. https://doi.org/10.3389/fpls.2022.1045417
Web Resources:	1. https://geneticliteracyproject.org 2. https://www.fao.org/biotech/en/ 3. https://www.isaaa.org/kc/default.asp

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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:	• 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:	**Foundational Techniques in Plant Genetic Engineering** 1.1 Culture and maintenance of plasmid-containing bacterial cultures and understanding of the vector map of plasmid. 1.2 Isolation of plasmid DNA. 1.3 Quantitative estimation of plasmid DNA using spectrophotometer. 1.4 Qualitative estimation of plasmid DNA using Agarose gel electrophoresis.	**8**	CO1, CO2,	K2, K3
Module 2:	**Amplification, Gene cloning and Transformation** 2.1 Preparation of *E. coli* (Dh5α) competent cells 2.2 Primer designing for gene amplification and RT PCR 2.3 Amplification of gene of interest for cloning 2.4 Digestion of plasmid DNA and gene of interest with restriction enzymes and size fractionation. 2.5 Ligation of digested DNA fragments. 2.6 Transformation of ligated plasmid in competent cells. 2.7 Screening of transformed bacterial cells by colony PCR. 2.8 Agrobacterium mediated leaf disc transformation and regeneration of plants.	**14**	CO1, CO2, CO3, CO4	K3, K4, K5, K6
Module 3:	**Gene expression studies and blotting** 3.1 cDNA synthesis using reverse transcriptase. 3.2 RT-PCR quantification of selected gene(s). 3.3 Use of software for gene expression quantification and comparative analysis. 3.4 Blotting techniques: Southern/Northern/Western blotting (any one).	**8**	CO1, CO2, CO3	K2, K3, K4, K5
Pedagogy:	Hands-on practicals, demonstrations			

Text Books:	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:	1. **Barampuram, S., & Zhang, Z. J.** (2023). Plant genetic transformation: Achievements, current status, and future outlook. Frontiers in Plant Science, 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. 3 Biotech, 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. Frontiers in Plant Science, 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. Frontiers in Plant Science, 13, 1045417. https://doi.org/10.3389/fpls.2022.1045417
Web Resources:	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

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Discipline Specific Elective (DSE) 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:	● 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:	**Module 1: Population and Spatial Ecology** **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. **1.2 Population Structure and Diversity Assessment**	**15**	**CO1, CO2, CO3**	**K1, K2, K3, K4**

	Frequency, density, abundance, species richness, evenness, Simpson's Index, Shannon-Wiener Index, quadrat and transect methods, rarefaction, alpha-beta-gamma diversity. **1.3 Spatial Ecology and Metapopulations** Metapopulation concepts, Levins model, source-sink dynamics, habitat fragmentation, patch occupancy, local extinction, metapopulation conservation, spatial heterogeneity. **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. **1.5 Species Distribution Modelling (SDM)** Environmental niche modelling (ENM), MaxEnt basics, GIS-based tools, ENM applications in ecology and conservation.			
Module 2:	**Module 2: Interactions, Evolution and Molecular Ecology** **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). **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. **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.	**15**	**CO1, CO3, CO4**	**K1, K2, K3, K4, K5**
Module 3:	**Module 3: Applied Ecology, EIA and Ecological Economics** **3.1 Conservation Biology and Global Change**	**15**	**CO5, CO6**	**K3, K4, K5, K6**

	Climate change biology, global environmental change, IPCC, SDGs, COP 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). **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. **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.			
Pedagogy:	Lectures, Assignments, Mini Projects, Field Visits, Group Discussion			
Text Books:	1. **Ambasht R.S. & Ambasht N.K.** (2023). A Textbook of Plant Ecology (16th Edition), CBS Publishers & distributors Pvt. Ltd., India. 2. **Canter L** (1996) Environmental Impact Assessment, 2nd Edition, McGraw Hill Publishing Company. 3. **Odum, E. P.** (2007) Fundamentals of Ecology, 5th edition, Thomson books. 4. **Sundara S.** R. (2003) Practical Manual of Plant Ecology and Plant Physiology, Anmol Publisher, India. 5. **Tiwari S.**C. (2005) Concepts of Modern Ecology. 1st Edition. M/s Bishen Singh Mahendra Pal Singh Publishers, India.			
References/ Readings:	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. 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.
Web Resources:	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/

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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:	● 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:	1. **Ambasht R.S. & Ambasht N.K.** (2023). A Textbook of Plant Ecology (16th Edition), CBS Publishers & distributors Pvt. Ltd., India. 2. **Canter L** (1996) Environmental Impact Assessment, 2nd Edition, McGraw Hill Publishing Company. 3. **Odum, E. P.** (2007) Fundamentals of Ecology, 5th edition, Thomson books. 4. **Sundara S.** R. (2003) Practical Manual of Plant Ecology and Plant Physiology, Anmol Publisher, India. 5. **Tiwari S.**C. (2005) Concepts of Modern Ecology. 1st Edition. M/s Bishen Singh Mahendra Pal Singh Publishers, India.			
References/ Readings:	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:	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/

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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:	• 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:	**Fundamentals of Plant Histology and Tissue Preparation** **1.1** Introduction to plant histology: Structure and organization of plant cells, tissues, and associated microorganisms **1.2** Chemistry and practice of fixation: Types of fixatives and their biological relevance **1.3** Techniques of sectioning: Whole mounts, hand sections, microtomy, cryo- and ultra-microtomy **1.4** Freeze-drying and preservation of biological specimens **1.5** Safety protocols and good histological practices	**10**	CO 1, CO 2	K1, K2, K3
Module 2:	**Microscopy Techniques and Image Analysis** **2.1** Light-matter interaction and its significance in microscopy **2.2** Kohler illumination and contrast-enhancement techniques	**12**	CO3, CO6	K2, K3, K4

	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) **2.4** Introduction to live-cell imaging and 3D tissue visualization **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 **2.6** Introduction to image analysis tools: Calibration and morphometric measurements; Overview of commonly used software (e.g., ImageJ/Fiji)			
Module 3:	**Histochemical and Cytochemical Localization of Biomolecules** **3.1** Cyto- and histo-chemistry using bright-field microscopy: **3.1.1** Single and double staining techniques **3.1.2** Localization of carbohydrates, proteins, lipids, and nucleic acids **3.1.3** Detection of phenolic compounds, lignins, cutins, suberin, waxes **3.1.4** Mineral detection: Calcium, potassium, iron, and other trace elements **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 **3.3** Autofluorescence and use of fluorochromes; Localization of proteins, lysine-rich proteins, nucleic acids, phytins; Use of FITC-bound dextrins and tissue-specific fluorochromes using fluorescent and bright-field microscopy. **3.4** Enzyme histochemistry: Localization of esterases, phosphatases, peroxidases, and other enzymes **3.5** Immunohistochemistry: Principle, antibody tagging, visualization, and relevance in plant sciences	**12**	CO4, CO5, CO6	K2, K3, K4, K5
Module 4:	**Module 4: Advanced Techniques and Applications in Histochemistry** **4.1** Electron microscopy: **4.1.1** Principles and instrumentation of SEM and TEM	**11**	CO5, CO6	K1, K2, K3, K4, K5, K6

	4.1.2 Specimen preparation, ultrathin sectioning, and contrast staining. **4.2** Histochemical localization of secondary metabolites: Alkaloids, terpenoids, flavonoids, and other bioactive compounds. **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 **4.4** Recent advances of histochemistry: Fluorescent biosensors and nano-tagging; AI-based tissue image analysis; Integration with omics and systems biology for diagnostics			
Pedagogy:	Lectures, Assignments, Seminars, Case Study Discussion, Group Discussion, Mini Projects.			
Text Books:	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.			
References/ Readings:	1. **Badria, F. A., & Aboelmaaty, W. S.** (2019). Plant Histochemistry: A versatile and indispensible tool in localization of gene expression, enzymes, cytokines, secondary metabolites and detection of plants infection and pollution. *Acta Scientific Pharmaceutical Sciences*, *3*(7), 88-100. 2. **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.

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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:	• 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 dextrins).	**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 crystals, stomata) using polarization microscopy.	**2**	CO1, CO2	K2, K3
	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:	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.
References/ Readings:	1. **David L. Spector and Robert D. Goldman.** (2006). Basic methods in microscopy, Cold Spring Harbor Laboratory Press, Cold Spring Harbor, New York. 2. **Demarco, D.** (2017). Histochemical analysis of plant secretory structures. In Histochemistry of single molecules (pp. 313-330). Humana Press, New York, NY. 3. **Gartner, L.P. and Hiatt, J.L.** (2006). Color Textbook of Histology e-book. Elsevier Health Sciences. 4. **Kiernan J.A.** (2015). Histological and Histochemical Methods: Theory and Practice (5th edition), Scion Publishing Ltd., U.K. 5. **Shyamasundari, K. and K. Rao H.** (2007). Histochemistry in focus. A Sourcebook of techniques and research needs, M.J.P. Publishers, Chennai. 6. **William A. Jensen.** (2015) Botanical Histochemistry: Principles and Practice. Agri Horti Press, India **7. Zhou, J. and Xi'an J.** (2017). Histochemistry, University Press Co. Germany: De Gruyter.

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SEMESTER III

Research Specific Elective (RSE) Courses

Title of the Course	Research Methodology
Course Code	BOT-6000
Number of Credits	4
Theory/Practical	Theory
Level	500
Effective from AY	2026-27
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	Yes

Pre-requisites for the Course:	Students should have undergone 400 level courses.	
Course Objectives:	• Train students in literature survey, citations, scientific writing, experimental design, and basic biostatistics. • Impart knowledge of data handling, advanced laboratory techniques, instrumentation and scientific communication necessary for research in plant sciences.	
Course Outcomes:	Students will be able to:	**Mapped to PSO**
	CO 1. Explain the principles of research design, hypothesis framing, and literature review.	PSO 1
	CO 2. Demonstrate appropriate sampling methods, data collection techniques, and statistical approaches in research.	PSO 1, PSO 3

	CO 3. Analyze and interpret experimental data using statistical tools and software.		PSO 1, PSO 3	
	CO 4. Develop research proposals, practice scientific writing, and effectively present research findings.		PSO 1, PSO 3, PSO 4	
	CO 5. Investigate the suitability of laboratory techniques and instrumentation for solving biological problems.		PSO 1, PSO 3	
	CO 6. Analyze research problems, frame hypothesis, and identify suitable methodologies for different research scenarios.		PSO 3, PSO 4	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	**1.1. Literature survey:** Identification of research problem and hypothesis formulation, literature review and databases, discriminative reading; bibliographic and webliography collection; literature citation; different system of citations, Journal abbreviations, reference management tools. **1.2. Experimental designs and biostatistics:** Principles of experimental design; sampling techniques: random, stratified, systematic; data acquisition in field and laboratory studies; data recording tools; database management systems for biological research; data presentation; biostatistics and data analysis; measures of central tendency and dispersion; probability distributions and hypothesis testing (t-test, chi-square, ANOVA); regression and correlation analysis; multivariate analysis: PCA, cluster analysis; software in data analysis. **1.3. Scientific writing and research ethics:** Importance of scientific writing; components of research proposals, scientific research articles, thesis, books and book chapters, scientific poster and presentation; use of visual aids and infographics; Plagiarism and research ethics; IPR databases; Patent databases, Non-Governmental databases, open access databases; data licensing and ownership.	**15**	CO1, CO2, CO3, CO4, CO6	K1, K2, K3, K4, K5, K6
Module 2:	**2.1. Laboratory practices and safety in the laboratory**: Research bioethics and good laboratory practices, general safety measures, chemical, physical, and biological hazards,	**15**	CO5, CO6	K1, K2, K3, K4

	spillage and waste disposal, disposal of radioactive waste, first aid, and Material Safety Datasheet (MSDS). **2.2. Centrifugation Techniques**: Basic principles of sedimentation; Relative Centrifugal Force (R.C.F.) and gravitational (g) force, density gradient centrifugation; design and care of rotors, safety aspects in the use of centrifuges. **2.3. Spectroscopic Techniques:** General principles; radiation energy and atomic structure; basic law of light absorption; types of spectra and their biological usefulness. Principle, application, and instrumentation of UV-VIS spectrophotometry; IR (infra-red) spectrophotometry; Spectrofluorometry, Atomic Absorption Spectroscopy (AAS) and Flame photometry; Mass spectrometry.			
Module 3:	**3.1. Chromatography Techniques**: General principles, techniques, and applications: Materials for column chromatography, adsorption, partition, molecular sieving, ion exchange, and affinity chromatography; factors influencing resolution. Column development – isocratic system and gradient solvent. Chromatogram reading, qualitative and quantitative determination of peaks. **3.2. Electrophoresis Techniques**: General principles, Gel electrophoresis of nucleic acids and proteins, Native PAGE, Sodium Dodecyl Sulphate-Polyacrylamide Gel Electrophoresis (SDS-PAGE), Isoelectric focusing and its application, 2D electrophoresis, Pulsed-field electrophoresis, Capillary electrophoresis, Blotting techniques: Detection, recovery, and estimation.	**15**	CO5, CO6	K1, K2, K3, K4
Module 4:	**4.1. Radiobiology**: Nature of radioactivity; atomic structure, stability, and radiation; isotopes; types of radioactive decay; detection and measurement of radioactivity; applications of radioisotopes in biological sciences; safety aspects for the use of radioisotopes; non-radioactive labelling. **4.2. Molecular techniques**: Flow Cytometry, Immuno-techniques, protein-protein interaction techniques, protein-nucleic acid interaction techniques, Protein Crystallography, Biosensors, Site-Directed Mutagenesis, Clustered Regularly Interspaced Short Palindromic Sequence/CRISPR Associated Genes (CRISPR/Cas).	**15**	CO5, CO6	K1, K2, K3, K4
Pedagogy:	Lectures/Tutorials/ICT-Tools/Assignments/Seminars/Peer discussions.			

Texts:	1. **Creswell, J. W.** (2022) Research design: Qualitative, quantitative, and mixed methods approaches (6th ed.). SAGE Publications. 2. **Gurumani, N.** (2006) Research methodology for biological sciences. M.J.P. Publishers, Chennai. 3. **Kothari, C. R.** (2019) Research methodology: Methods and techniques. (4th ed.). New Age International Publishers. 4. **Kumar, R.** (2019) Research methodology: A step-by-step guide for beginners. (5th ed.). SAGE Publications. 5. **Morris, A. S. & Langari, R.** (2020) Measurement and instrumentation: Theory and application (3rd ed.). Academic Press. 6. **Rouessac, F. & Rouessac, A.** (2022) Chemical analysis: Modern instrumentation methods and techniques (3rd ed.). Wiley-Blackwell.
References/ Readings:	1. **Bailey, P. L.** (1980) Analysis and ion selective electrodes 2nd Ed. Heyden, London. 2. **Bauman, R. P.** (1981) Absorption Spectroscopy. John Wiley, New York 3. **Day, R. A. & Gastel B.** (2016) How to write and publish a scientific paper, Cambridge University Press. 4. **Dixon, R. N.** (1965) Spectroscopy and Structure. Mathuen, London 5. **Giddings, J. C.** (2002) Principles and Theory, Dynamics of Chromatography Part I Dekker, New York. 6. **Grob, R. L.** (2004) Modern Practices of Gas Chromatography. 2nd Ed. John Wiley, New York. 7. **Gurumani, N.** (2005) An Introduction to Biostatistics, M.J.P. Publishers, Chennai. 8. **Hames, B. D., & Rickwood, D.** (1998) Gel electrophoresis of Proteins: A practical approach 2nd ed. IRL Press, Oxford. 9. **Hofmann, A., & Clokie, S.** (2018) Wilson and Walker's Principles and Techniques of Biochemistry and Molecular Biology, Cambridge University Press. 10. **Jacob, R.**, **Alexander, D., & Lane, L.** (2018) A guidebook to Intellectual property:Patent, trademarks, copyrights and design. Sweet and Maxwell ltd, UK. 11. **Karp, G.** (2009) Cell and molecular biology: Concepts and experiments, 7th edition. John Wiley and Sons, U.S.A. 12. **Marini, R. P.** (2024) Experimental Designs and Statistical Analyses for Rootstock Trials. Agronomy, 14(10), 2312. 13. **Myneni, S.** R. (2019) Patent Drafting and Specification Writing. New Era Law Publication, Haryana. 14. **Reece, R. J.** (2004) Analysis of genes and genomes. John Wiley and Sons Ltd.

	15. **Saraswathy, N., & Ramalingam, P.** (2011) Concepts and Techniques in Genomics and Proteomics. Biohealthcare Publishing (Oxford) Limited, New York. 16. **Sharma, B. K.** (2006) Principal of analytical chemistry, Meerut Publication, Meerut. 17. **Walker, J. M., & Rapley, R.** (2008) Molecular Biomethods Handbook, Hertfordshire, U.K. 18. **Willard, H. F., Merritt, L.L., Dean, J.A. & Settle, F. A.** (1988) Instrumental Method of analysis. C.B.S. Publishers and distribution, New Delhi 19. **Yau, W. W., Kirkland, J. J. & Bly, D. D.** (2009) Modern size exclusion chromatography, Wiley Interscience, New York.
Web Resources:	1. https://www.euacademic.org/BookUpload/9.pdf 2. https://iimm.org/wp-content/uploads/2024/09/IIMM_RESEARCH-METHODOLOGY-LOCKED-BOOK-revised.pdf 3. https://study.sagepub.in/kumar_rm4e 4. https://petex.utexas.edu/publications/books/measurement-control-and-storage/266-basic-instrumentation-4th 5. https://open.umn.edu/opentextbooks/textbooks/measurement-and-instrumentation-an-introduction-to-concepts-and-methods

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Title of the Course	Pharmacognosy and Phytochemistry
Course Code	BOT-6001
Number of Credits	3
Theory/Practical	Theory
Level	500
Effective from AY	2026-27
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	Yes

Pre-requisites for the Course:	Students who have undergone 400-level core courses.	
Course Objectives:	• Understand the fundamentals and historical perspective of pharmacognosy and phytochemistry, including traditional systems of medicine. • Explore primary and secondary metabolites, their biosynthesis, and significance in drug discovery. • Develop skills in extraction, isolation, purification, and analysis of plant metabolites using modern analytical tools. • Evaluate pharmacological applications, safety, and regulatory standards of herbal drugs. • Appreciate modern trends in phytomedicine, including bioprospecting, synthetic biology, and nanotechnology-based drug delivery.	
Course Outcomes:	Students will be able to:	**Mapped to PSO**
	CO 1. Describe the history, scope, and significance of pharmacognosy, including traditional medicinal systems and crude drug classification.	PSO 1, PSO 2

	CO 2. Apply knowledge of primary and secondary metabolites, extraction techniques, and phytochemical screening for plant-based research.		PSO 1, PSO 3	
	CO 3. Analyze biosynthetic pathways, metabolite profiling, and chemotaxonomic relationships using modern analytical and biotechnological approaches.		PSO 1, PSO 3	
	CO 4. Evaluate pharmacological activities, safety, quality control, and regulatory standards of herbal drugs in research and industry.		PSO 2, PSO 4	
	CO 5. Develop strategies for bioprospecting, drug discovery, and modern phytomedicine applications using emerging technologies such as synthetic biology, nanotechnology, and nutraceuticals.		PSO 3, PSO 4	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	**Fundamentals of Pharmacognosy and Phytochemistry** **1.1.** History, scope, and significance of pharmacognosy in drug discovery. **1.2.** Traditional systems of medicine: Ayurveda, Siddha, Unani, Chinese medicine. **1.3.** Crude drugs: Sources (plant, animal, marine), classification (morphological, pharmacological, chemical, ethnobotanical). **1.4.** Adulteration of crude drugs: types, causes, detection, and prevention; role of Herbarium pharmaceutical research. **1.5.** Primary and secondary metabolites: Distribution, function, and significance.	**15**	CO 1, CO 2	K1, K2, K3
Module 2:	**<u>Advanced Phytochemistry and Analytical Approaches</u>** **2.1.** Biosynthetic pathways of major secondary metabolites (alkaloids, terpenoids, flavonoids, glycosides, tannins, saponins, phenolics). **2.2.** Plant tissue culture and biotechnological approaches for metabolite production. **2.3.** Extraction, isolation, purification techniques: conventional vs. green methods. **2.4.** Modern analytical tools: HPTLC, HPLC, GC-MS, LC-MS/MS, NMR, MS, FTIR. **2.5.** Metabolite profiling, chemotaxonomy, metabolomics, transcriptomics, and proteomics approaches.	**15**	CO 2, CO 3	K1, K2, K3, K4

	2.6. Quality control and standardization of herbal drugs (WHO guidelines, AYUSH, and global pharmacopoeial standards).			
Module 3:	**Pharmacological Applications, Safety, and Modern Trends** **3.1.** Biological activities of phytochemicals: Antioxidant, anticancer, antimicrobial, neuroprotective, anti-inflammatory. **3.2.** Bioassays and screening methods (*in vitro*, *in vivo*, cell-based assays). **3.3.** Toxicology and safety evaluation of herbal drugs. **3.4.** Drug discovery and development: lead compounds, molecular docking, Quantitative structure-activity relationship (QSAR), SAR studies. **3.5.** Ethnopharmacology and bioprospecting: Traditional knowledge to novel drugs. **3.6.** Intellectual property rights (IPR) and regulatory aspects in herbal drug research. **3.7.** Emerging trends: Synthetic biology, nanotechnology-based delivery systems, nutraceuticals, functional foods, personalized phytomedicine, role of AI in pharmacopoeia.	**15**	CO4, CO5	K4, K5, K6
Pedagogy:	Lectures/Interactive Tutorials/ICT tools/Concept-based Assignments/Critical Reading/Peer Discussions/Seminars.			
Texts:	1. **Arundhati, Deokar., Madhav, Chakolkar., & Tapadiya, G. G.** (2024) A Practical Book of Pharmacognosy and Phytochemistry II, Nirali Prakashan, India. 2. **Biren, Shah., & Seth, A. K.** (2019) Textbook of Pharmacognosy and Phytochemistry, CBS; 2nd edition, CBSPD, India. 3. **Lakshmi, Devi. S.** (2023) A Practical Hand Book of Pharmacognosy and Phytochemistry – II, Bluerose Publishers Pvt. Ltd.; First Edition, UP, India.			
References/ Readings:	1. **Alla, P. Toropova., & Andrey, A. Toropova** (2023) QSPR/QSAR Analysis Using SMILES and Quasi-SMILES: 33 (Challenges and Advances in Computational Chemistry and Physics), Springer International Publishing AG, India. 2. **Bhushan Patwardhan., Gururaj, Mutalik. M. D., & Girish, Tillu.** (2015) Integrative Approaches for Health: Biomedical Research, Ayurveda and Yoga 1st Edition, Academic Press, India.			

	3. **Cahlíková, L., Šafratová, M., Hošťálková, A., Chlebek, J., Hulcová, D., Breiterová, K., & Opletal, L.** (2020) Pharmacognosy and its role in the system of profile disciplines in pharmacy. Natural Product Communications, 15(9), 4. **Chandrakant, Kokare.** (2019) Pharmaceutical Biotechnology Paperback – 1, First Edition, Nirali Prakashan; India. 5. **Hong-guang, Xie.** (2022) Applying Pharmacogenomics in Therapeutics, CRC Press, India 6. **Heinrich, M., Barnes, J., Prieto-Garcia, J., Gibbons, S., & Williamson, E. M.** (2017) Fundamentals of Pharmacognosy and Phytotherapy E-Book: Fundamentals of Pharmacognosy and Phytotherapy E-Book. Elsevier Health Sciences. 7. **Kiplimo, Joyce. & Koorbanally, Neil. (2014)** Phytochemistry and Biological Activity of Secondary Metabolites, LAP Lambert Academic Publishing, India. 8. **Md, Rafiul. Haque.** (2022) Pharmacognosy and Phytochemistry I Theory and Practical Kindle Edition, CBS Publishers and Distributors Pvt Ltd., India. 9. **Munir, Ozturk., & Khalid, Rehman. Hakeem.** (2019) Plant and Human Health, Volume 2: Phytochemistry and Molecular Aspects, Springer Nature Switzerland. 10. **Odoh, U. E., Tijjani, H., & Egbuna, C.** (Eds.) (2024) Advances in Pharmacognosy and Phytochemistry of Diabetes. IPS Intelligentsia Publishing Services. 11. **Rajeshwari, T. S.** (2019) Current Trends in Pharmacognosy and Phytochemistry II (Theory cum Practical), S Vikas and Company, India. 12. **Sadhu, P., Kumari, M., Parmar, G., & Talele, C.** (2025) Molecular Pharmacognosy. Pharmacognosy and Phytochemistry: Principles, Techniques, and Clinical Applications, 395-420. 13. **Saxena, M., Saxena, J., Nema, R., Singh, D., & Gupta, A.** (2013) Phytochemistry of medicinal plants. Journal of pharmacognosy and phytochemistry, 1(6). 14. **Solanki, A. & Zaveri, M.** (2012) Pharmacognosy, phytochemistry and pharmacology of *Abrus precatorius* leaf: A review. International Journal of Pharmaceutical Sciences Review and Research, 13(2), 71-76. 15. **Udaykumar, P.** (2021) Medical Pharmacology, 7th Ed, CBSPD, New-Delhi, India. 16. **Vijai, Malik., & Pranita Malik** (2023) Economic Botany, Ethnomedicine & Phytochemistry, Pragati Prakashan, New-Delhi.
Web Resources:	1. https://pubmed.ncbi.nlm.nih.gov/ 2. https://www.nature.com/articles/s41598-018-22631-z

	3. https://cb.imsc.res.in/imppat/

Title of the Course	Lab in Pharmacognosy and Phytochemistry
Course Code	BOT-6002
Number of Credits	1
Theory/Practical	Practical
Level	500
Effective from AY	2026-27
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	Yes

Pre-requisites for the Course:	Students who have undergone 400-level core courses.	
Course Objectives:	• Develop practical skills in identification, extraction, separation, and analysis of primary and secondary metabolites from plant materials. • Evaluate the chemical composition and biological potential of plant extracts using modern analytical and spectrometric techniques. • Apply knowledge of pharmacological assays to assess antioxidant, antimicrobial, and bioactive properties of plant-derived compounds. • Integrate theoretical and practical knowledge for quality assessment, adulteration detection, and phytochemical profiling of medicinal plants.	
Course Outcomes:	Students will be able to:	**Mapped to PSO**
	CO 1. Identify and describe macroscopic, microscopic, and phytochemical characteristics of selected medicinal plants.	PSO 1, PSO 2

	CO 2. Perform extraction, separation, and qualitative/quantitative analysis of primary and secondary metabolites from plant materials.		PSO 1, PSO 3	
	CO 3. Analyze and interpret phytochemical profiles and physicochemical parameters to evaluate quality and composition of crude drugs.		PSO 1, PSO 2, PSO 3	
	CO 4. Evaluate biological activities and quantify bioactive metabolites using laboratory techniques.		PSO 2, PSO 3	
	CO 5. Design and implement comparative phytochemical studies across plant parts or species, and critically evaluate crude drugs for adulteration or variation using standard chemical and microscopic methods.		PSO 1, PSO 3, PSO 4	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	**Fundamentals of Pharmacognosy and Phytochemistry** **1.1.** Macroscopic and microscopic identification of selected crude drugs – Leaves, roots, seeds, and barks. **1.2.** Qualitative analysis of primary and secondary metabolites – Carbohydrates (Molisch's, Benedict's), Proteins (Biuret), Alkaloids (Mayer's, Dragendorff's), Phenols/Tannins (Ferric chloride), Flavonoids/Glycosides (Shinoda, Keller-Killiani), Saponins (Foam test), Steroids (Liebermann-Burchard). **1.3.** Detection and identification of adulterants in crude drugs – Using standard chemical and microscopic tests. **1.4.** Determination of physicochemical parameters of crude drugs – Moisture content, total ash, and extractive values. **1.5.** Phytochemical profiling of selected medicinal plant extracts – Compilation of qualitative test results to compare metabolite distribution in plants using standards.	**10**	CO 1, CO 5	K1, K2, K4, K5
Module 2:	Extraction, separation, and analysis of plant metabolites **2.1.** Extraction of secondary metabolites using maceration or Soxhlet extraction.	**10**	CO 2, CO 3, CO 5	K3, K4, K6

	2.2. Thin Layer Chromatography (TLC) for visualization and identification of phytochemicals. **2.3.** Separation of alkaloids, flavonoids, and phenols using simple solvent partitioning or column chromatography. **2.4.** Quantitative estimation of total phenolics. **2.5.** Quantitative estimation of total flavonoids.			
Module 3:	**Pharmacological Applications** **3.1.** *In vitro* antioxidant activity assays. **3.2.** Antimicrobial screening of plant extracts using agar well diffusion method. **3.3.** Estimation of alkaloid content in selected plant samples. **3.4.** Estimation of saponins or tannins in selected plant samples. **3.5.** Comparative study of phytochemical content in different plant parts (leaves, roots, seeds) using spectrometric tests.	**10**	CO 4, CO 5, CO 3	K3, K4, K5, K6
Pedagogy:	Hands-on Practicals, Demonstrations, Mini projects			
Texts:	1. **Arundhati, Deokar., Madhav, Chakolkar., & G. G. Tapadiya.** (2024) A Practical Book of Pharmacognosy and Phytochemistry II, Nirali Prakashan, India 2. **Biren, Shah., & A. K. Seth** (2019) Textbook of Pharmacognosy and Phytochemistry, CBS; 2nd edition, CBSPD, India. 3. **Lakshmi, Devi. S.** (2023) A Practical Hand Book of Pharmacognosy and Phytochemistry – II, Bluerose Publishers Pvt. Ltd.; First Edition, UP, India.			
References/ Readings:	1. **Alla, P., Toropova, Andrey., & Toropov, A.** (2023) QSPR/QSAR Analysis Using SMILES and Quasi-SMILES: 33 (Challenges and Advances in Computational Chemistry and Physics), Springer International Publishing AG, India. 2. **Bhushan, Patwardhan., Gururaj, Mutalik. M. D., & Girish, Tillu.** (2015) Integrative Approaches for Health: Biomedical Research, Ayurveda and Yoga 1st Edition, Academic Press, India. 3. **Cahlíková, L., Šafratová, M., Hošťálková, A., Chlebek, J., Hulcová, D., Breiterová, K., & Opletal, L.** (2020) Pharmacognosy and its role in the system of profile disciplines in pharmacy. Natural Product Communications, 15(9).			

4. **Chandrakant, Kokare.** (2019) Pharmaceutical Biotechnology Paperback – 1, First Edition, Nirali Prakashan; India.
5. **Hong-guang, Xie.** (2022) Applying Pharmacogenomics in Therapeutics, CRC Press, India.
6. **Heinrich, M., Barnes, J., Prieto-Garcia, J., Gibbons, S., & Williamson, E. M.** (2017) Fundamentals of Pharmacognosy and Phytotherapy E-Book: Fundamentals of Pharmacognosy and Phytotherapy E-Book. Elsevier Health Sciences.
7. **Kiplimo, Joyce., & Koorbanally, Neil. (2014)** Phytochemistry and Biological Activity of Secondary Metabolites, LAP Lambert Academic Publishing, India.
8. **Md, Rafiul. Haque.** (2022) Pharmacognosy and Phytochemistry I Theory and Practical Kindle Edition, CBS Publishers and Distributors Pvt Ltd., India.
9. **Munir, Ozturk., & Khalid, Rehman. Hakeem.** (2019) Plant and Human Health, Volume 2: Phytochemistry and Molecular Aspects, Springer Nature Switzerland.
10. **Odoh, U. E., Tijjani, H. & Egbuna, C.** (Eds.) (2024) Advances in Pharmacognosy and Phytochemistry of Diabetes. IPS Intelligentsia Publishing Services.
11. **Rajeshwari, T. Sudha.** (2019) Current Trends in Pharmacognosy and Phytochemistry II (Theory cum Practical), S Vikas and Company, India.
12. **Sadhu, P., Kumari, M., Parmar, G., & Talele, C.** (2025) Molecular Pharmacognosy. Pharmacognosy and Phytochemistry: Principles, Techniques, and Clinical Applications, 395-420.
13. **Saxena, M., Saxena, J., Nema, R., Singh, D., & Gupta, A.** (2013) Phytochemistry of medicinal plants. Journal of pharmacognosy and phytochemistry, 1(6).
14. **Solanki, A., & Zaveri, M.** (2012) Pharmacognosy, phytochemistry and pharmacology of Abrus precatorius leaf: A review. International Journal of Pharmaceutical Sciences Review and Research, 13(2), 71-76.
15. **Udaykumar, P.** (2021) Medical Pharmacology, 7th Ed, CBSPD, New-Delhi, India
16. **Vijai, Malik., & Pranita, Malik.** (2023) Economic Botany, Ethnomedicine & Phytochemistry, Pragati Prakashan, New-Delhi.

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Title of the Course	Genome Informatics
Course Code	BOT-6003
Number of Credits	3
Theory/Practical	Theory
Level	500
Effective from AY	2026-27
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	Yes

Pre-requisites for the Course:	Prior knowledge of Plant Molecular Biology and Genetics and familiarity with basic Bioinformatics tools.	
Course Objectives:	• Introduce students to the principles of genome organization, sequencing, and genome databases. • Develop skills in sequence analysis, genome annotation, multiple sequence alignment, and phylogenetic analysis. • Familiarize students with structural biology, molecular modeling, docking, and drug design applications. • Prepare students to apply genome informatics tools for crop improvement, biotechnology, and evolutionary studies.	
Course Outcomes:	Students will be able to:	**Mapped to PSO**
	CO 1. Understand genome organization, sequencing methods, and biological databases.	PSO1
	CO 2. Apply genome informatics tools for sequence alignment, phylogenetic analysis, and annotation.	PSO1, PSO2, PSO3

	CO 3. Analyze and evaluate comparative genomics, structural motifs, and macromolecular interactions.		PSO1, PSO2, PSO3	
	CO 4. Create structural models, perform docking studies, and propose genome/structure-based solutions in crop biotechnology and drug discovery.		PSO3, PSO4	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	**Genome organization and databases** **1.1.** Genome organization in prokaryotes and eukaryotes. **1.2.** Plant genome size variation, coding and non-coding regions, repetitive DNA. **1.3.** Genome sequencing technologies: Sanger, NGS, PacBio, Nanopore. **1.4.** Plant genome projects and databases of model plants and crop plants **1.5.** Genome databases: GenBank, EMBL, DDBJ, Ensembl, Gramene, TAIR, EXPASY, PROSITE, STRING, PDB, UNIPROT, SNPdb, MMDb, OMIM **1.6.** Database search engines, Sequence formats and retrieval, RefSeq **1.7.** Web based and Command lines softwares	**15**	CO1	K1, K2
Module 2:	**Sequence analysis and comparative genomics** **2.1.** Similarity searches, Local and Global alignment scoring matrices **2.2.** Multiple sequence alignment: Clustal Omega, MUSCLE, MAFFT. **2.3.** Phylogenetic analysis methods: distance and character based, UPGMA, neighbour joining, parsimony, maximum likelihood, Bayesian. **2.4.** Tools for tree construction and case studies in evolutionary biology. **2.5.** Barcoding and its applications and Limitations, Consortium for Barcode of Life (CBOL), Barcode of Life Database (BOLD). **2.6.** Analysis of Genome sequence, promoter analysis, RNA-seq analysis, DEGs. **2.7.** Genome annotation: ab initio and homology-based, Functional annotation KEGG, Gene Ontology. **2.8.** Gene prediction methods and tools.	**15**	CO2, CO3	K3, K4, K5

	2.9. Comparative genomics: orthologs, paralogs, synteny, duplication events, polyploidy.			
Module 3:	**Structural bioinformatics and applications** **3.1.** Macromolecules tertiary quaternary structures, Ramachandran Plot **3.2.** Protein motif/domain search databases, Pfam, InterPro, SMART, Prosite. **3.3.** Structural databases, PDB, RCSB, UniProt structural features. **3.4.** Visualization and simulation of macromolecular structures, protein folding, CATH, SCOP databases **3.5.** Concepts in molecular modelling and methods in Homology modeling **3.6.** Molecular docking and ligand binding studies **3.7.** Molecular dynamics simulations. **3.8.** Macromolecular interactions, Protein-Protein, Protein-DNA, Protein RNA interactions **3.9.** Case studies: Plant proteins in stress biology, enzyme function prediction, structure-based drug design. **3.10.** Applications in drug discovery and phytochemical docking in medicinal plants.	**15**	CO3, CO4	K4, K5, K6
Pedagogy:	Lectures/ICT tools/Seminar/ Demonstrations on data analysis/Presentations.			
Texts:	1. **Antao, T.** (2018) Bioinformatics with Python Cookbook. Packt Publishing Ltd. 2. **Attwood, T. K., Parry-Smith, D. J., & Phukan, S.** (2022) Introduction to Bioinformatics. Pearson Education (Singapore) Pvt. Ltd. 3. **Baxevanis, A. D., & Ouellette, B. F. F.** (2004) Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins (3rd ed.) John Wiley & Sons. 4. **Campbell, A. M., & Heyer, L. J.** (2021) Discovering Genomics, Proteomics and Bioinformatics (3rd ed.) Benjamin Cummings. 5. **Davies, T. M.** (2016) The Book of R: A First Course in Programming and Statistics. No Starch Press. 6. **Lesk, A. M.** (2019) Introduction to Bioinformatics (5th ed.). Oxford University Press. 7. **Mount, D. W.** (2004) Bioinformatics: Sequence and Genome Analysis (2nd ed.). Cold Spring Harbor Laboratory Press.			

	8. **Rastogi, S. C., Mendiratta, N., & Rastogi, P.** (2013) Bioinformatics: Methods and Applications, Genomics, Proteomics and Drug Discovery (4th ed.). Prentice Hall of India Pvt. Ltd.
References/ Readings:	1. **Baxevanis, A. D., Davison, D. B., Page, R. D. M., & Petsko, G. A.** (2004) Current Protocols in Bioinformatics. John Wiley & Sons. 2. **Bujnicki, J. M., Droogmans, L., Grosjean, H., Purushothaman, S. K., & Lapeyre, B**. (2008) Practical Bioinformatics. Springer. 3. **Fasman, G. D.** (1989) Prediction of Protein Structure and the Principles of Protein Conformation. Plenum Press. 4. **Friesner, R. A., Prigogine, L., & Rice, S. A.** (Eds.). (2002) Computational Methods for Protein Folding: Advances in Chemical Physics (Vol. 120). John Wiley & Sons. 5. **Gimona, M., Cesareni, G., Yaffe, M., & Sudol, M.** (Eds.). (2004) Modular Protein Domains. Wiley-VCH Verlag. 6. **Gundertofte, K., & Jorgensen, F. S.** (2000) Molecular Modelling and Prediction of Bioactivity. Kluwer Academic Publishers. 7. **Leach, A. R.** (2001) Molecular Modelling: Principles and Applications (2nd ed.). Prentice Hall. 8. **Maulik, U., Bandyopadhyay, S., & Mukhopadhyay, A.** (2011) Multiobjective Genetic Algorithms for Clustering: Applications in Data Mining and Bioinformatics. Springer. 9. **Misener, S., & Krawetz, S.** (2004) Bioinformatics: Methods and Protocols (Methods in Molecular Biology, Vol. 132). Humana Press. 10. **Pevsner, J.** (2015) Bioinformatics and Functional Genomics (3rd ed.). Wiley Blackwell. 11. **Solomon, K. A**. (2011) Molecular Modelling and Drug Design. MJ Publishers. 12. **Stekel, D.** (2003) Microarray Bioinformatics. Cambridge University Press. 13. **Webster, D. M.** (Ed.). (2000) Protein Structure Prediction: Methods and Protocols. Humana Press.
Web Resources:	1. https://ncbi.nlm.nih.gov 2. https://plants.ensembl.org 3. https://www.gramene.org 4. https://www.rcsb.org 5. https://swissmodel.expasy.org 6. https://www.genome.jp/kegg/

	7. https://www.arabidopsis.org 8. https://string-db.org 9. https://www.ebi.ac.uk/training/online/

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Title of the Course	Lab in Genome Informatics
Course Code	BOT-6004
Number of Credits	1
Theory/Practical	Practical
Level	500
Effective from AY	2026-27
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	Yes

Pre-requisites for the Course:	Corresponding theory course BOT-6003 and basic knowledge of molecular biology, and bioinformatics tools. Familiarity with operating computers.	
Course Objectives:	• Develop practical skills in working with genomic and proteomic datasets. • Provide hands-on experience in sequence analysis, genome annotation, and NGS data interpretation. • Enable students to analyse and interpret biological questions using computational approaches.	
Course Outcomes:	Students will be able to:	**Mapped to PSO**
	CO 1. Explore computational tools and retrieve sequences from genome and protein databases.	PSO1, PSO3
	CO 2. Perform sequence alignments, BLAST searches, phylogenetic analysis, and promoter/cis-element analysis.	PSO1, PSO3
	CO 3. Analyse physicochemical properties, macromolecular interactions, and perform structural modelling.	PSO1, PSO3, PSO4

	CO 4. Evaluate NGS raw data, map reads, perform functional annotation to investigate plant molecular responses.		PSO1, PSO2, PSO3	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	**1.1.** Exploration of genome and protein databases. **1.2.** Retrieval of DNA/RNA/protein sequences in different sequence formats, GEO datasets. **1.3.** Homology search: types of BLAST (blastn, blastp, blastx, tblastn, tblastx, PSI-BLAST, PHI-BLAST) **1.4.** Pairwise and multiple sequence alignments (Needleman-Wunsch Algorithm, Smith-Waterman Algorithm, EMBOSS Needle, EMBOSS Matcher, Clustal Omega, MUSCLE, MAFFT **1.5.** Phylogenetic tree construction (UPGMA, NJ, Maximum Parsimony, maximum likelihood) and evolutionary studies. **1.6.** Promoter and cis-regulatory elements analysis. **1.7.** Gene prediction tools. **1.8.** Physicochemical properties of proteins. **1.9.** Domain/motif search using Pfam, InterPro, PROSITE. **1.10.** Protein–protein interaction analysis using STRING database **1.11.** Protein structural visualization, Homology modelling and molecular docking. **1.12.** Quality check of raw reads, adapter trimming. **1.13.** Mapping reads to reference genome. **1.14.** Functional annotation, KEGG. **1.15.** DEGs analysis Gene ontology studies.	**30**	CO1, CO2, CO3, CO4	K1, K2, K3, K4, K5
Pedagogy:	Hands-on practicals/mini-projects and assignments on sequence/ analysis and NGS data analysis			
Texts:	1. **Antao, T.** (2018) Bioinformatics with Python Cookbook. Packt Publishing Ltd.			

	2. **Attwood, T. K., Parry-Smith, D. J., & Phukan, S.** (2022) Introduction to Bioinformatics. Pearson Education (Singapore) Pvt. Ltd. 3. **Baxevanis, A. D., & Ouellette, B. F. F.** (2004) Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins (3rd ed.). John Wiley & Sons. 4. **Campbell, A. M., & Heyer, L. J.** (2021) Discovering Genomics, Proteomics and Bioinformatics (3rd ed.) Benjamin Cummings. 5. **Davies, T. M.** (2016) The Book of R: A First Course in Programming and Statistics. No Starch Press. 6. **Lesk, A. M.** (2019) Introduction to Bioinformatics (5th ed.). Oxford University Press. 7. **Mount, D. W.** (2004) Bioinformatics: Sequence and Genome Analysis (2nd ed.). Cold Spring Harbor Laboratory Press. 8. **Rastogi, S. C., Mendiratta, N., & Rastogi, P.** (2013) Bioinformatics: Methods and Applications, Genomics, Proteomics and Drug Discovery (4th ed.). Prentice Hall of India Pvt. Ltd.
References/ Readings:	1. **Baxevanis, A. D., Davison, D. B., Page, R. D. M., & Petsko, G. A.** (2004) Current Protocols in Bioinformatics. John Wiley & Sons. 2. **Bujnicki, J. M., Droogmans, L., Grosjean, H., Purushothaman, S. K., & Lapeyre, B**. (2008) Practical Bioinformatics. Springer. 3. **Fasman, G. D.** (1989) Prediction of Protein Structure and the Principles of Protein Conformation. Plenum Press. 4. **Friesner, R. A., Prigogine, L., & Rice, S. A.** (Eds.). (2002) Computational Methods for Protein Folding: Advances in Chemical Physics (Vol. 120). John Wiley & Sons. 5. **Gimona, M., Cesareni, G., Yaffe, M., & Sudol, M.** (Eds.). (2004) Modular Protein Domains. Wiley-VCH Verlag. 6. **Gundertofte, K., & Jorgensen, F. S.** (2000) Molecular Modelling and Prediction of Bioactivity. Kluwer Academic Publishers. 7. **Leach, A. R.** (2001) Molecular Modelling: Principles and Applications (2nd ed.). Prentice Hall. 8. **Maulik, U., Bandyopadhyay, S., & Mukhopadhyay, A.** (2011) Multiobjective Genetic Algorithms for Clustering: Applications in Data Mining and Bioinformatics. Springer. 9. **Misener, S., & Krawetz, S.** (2004) Bioinformatics: Methods and Protocols (Methods in Molecular Biology, Vol. 132). Humana Press. 10. **Pevsner, J.** (2015) Bioinformatics and Functional Genomics (3rd ed.). Wiley Blackwell.

	11. **Solomon, K. A**. (2011) Molecular Modelling and Drug Design. MJ Publishers. 12. **Stekel, D.** (2003) Microarray Bioinformatics. Cambridge University Press. 13. **Webster, D. M.** (Ed.). (2000) Protein Structure Prediction: Methods and protocols. Humana Press.
Web Resources:	1. https://www.ncbi.nlm.nih.gov/ 2. https://plants.ensembl.org/ 3. https://ncbi.nlm.nih.gov/ 4. http://bioinformatics.psb.ugent.be/webtools/plantcare/html/ 5. https://string-db.org/ 6. https://pfam.xfam.org/ 7. https://swissmodel.expasy.org/ 8. https://www.ncbi.nlm.nih.gov/geo/

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Title of the Course	Plant Omics
Course Code	BOT-6005
Number of Credits	4
Theory/Practical	Theory
Level	500
Effective from AY	2026-27
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	Yes

Pre-requisites for the Course:	Basic knowledge of genome, genes, proteins and metabolism	
Course Objectives:	• Introduce students to the concepts, and methodologies of genomics, transcriptomics, proteomics, and metabolomics. • Provide an understanding of high-throughput technologies and analytical methods used in Omics studies. • Enable students to interpret biological data from genome, transcriptome, proteome, and metabolome studies. • Develop the ability to analyze molecular pathways, signaling networks, and plant-environment interactions.	
Course Outcomes:	Students will be able to:	**Mapped to PSO**
	CO 1. Explain and compare fundamental concepts in genomics, transcriptomics, proteomics, and metabolomics.	PSO1
	CO 2. Analyse sequencing platforms, transcriptomic and gene expression datasets.	PSO1, PSO3
	CO 3. Interpret post-translational modifications, protein-protein interactions, and metabolomic data for functional insights.	PSO1, PSO2, PSO3

	CO 4. Evaluate and design Omics-based experimental strategies for plant research and system biology approach.		PSO1, PSO2, PSO3, PSO4	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	**Genomics & Epigenomics** **1.1** Classical genomics and Mendelian genetics, forward/reverse genetics, linking genotype to phenotype, mutant screening. **1.2** Large-scale genome sequencing: Platforms for NGS, second and third-generation sequencing, whole genome sequencing, targeted sequencing. **1.3** Chromatin Immunoprecipitation sequencing (ChIP-seq) and its applications. **1.4** Genome assembly strategies: de-novo vs reference based assembly. **1.5** Structural variation and SNP analysis in plants. **1.6** Epigenomics: Epigenetic modifications, plant mediator complex. **1.7** Epigenome-wide association studies (EWAS) in plants. **1.8** Integration of genomics and epigenomics **1.9** Metagenomics: Sample collection, library preparation, sequencing, microbial community analysis.	**20**	CO1, CO2	K1, K2, K3, K4
Module 2:	**Transcriptomics & Gene expression analysis** **2.1** Overview of transcriptome and RNA biology: mRNA, non-coding RNAs, alternative splicing. **2.2** RNA sequencing (RNA-Seq): Library preparation, sequencing, read mapping. **2.3** Differential gene expression analysis using DESeq2/ EdgeR. **2.4** Microarray analysis: Principles, cDNA arrays, data normalization. **2.5** Functional annotation and pathway enrichment (GO, KEGG). **2.6** ENCODE project overview and its plant equivalents. **2.7** Long-read transcriptomics (PacBio, Nanopore) for isoforms.	**10**	CO1, CO2	K2, K3, K4, K5

	2.8 Metatranscriptomics: Sample collection, RNA extraction, library preparation, sequencing, microbial community analysis.			
Module 3:	**Proteomics & Protein networks** **3.1** Protein structure, folding, function, and amino acid properties. **3.2** Post-translational modifications: Glycosylation, phosphorylation, acetylation, methylation, ubiquitinylation, sumoylation. **3.3** Protein transport, targeting, secretion, ER/Golgi dynamics. **3.4** Protein degradation: Ubiquitin-proteasome system, lysosomal proteolysis, autophagy. **3.5** Protein-protein interactions: Motifs, multi-protein complexes. **3.6** Plant signaling networks: Membrane receptors, G-protein coupled receptors, enzyme linked receptors, ion channels, pattern recognition receptors, signalling pathways. **3.7** Proteomic techniques: 2D electrophoresis, MS-ESI, MALDI-TOF, protein microarrays, quantitative proteomics (iTRAQ, TMT). **3.8** Structural bioinformatics: Homology modeling, docking.	**20**	CO3	K2, K3, K4, K5
Module 4:	**Metabolomics and multi-Omics integration** **4.1** Metabolites overview, metabolic pathways, metabolite profiling. **4.2** Sample preparation, extraction, derivatization. **4.3** Targeted vs untargeted metabolomics, mass spectrometry, NMR. **4.4** Metabolomic data analysis: Molecular feature identification, structural confirmation, pathway mapping. **4.5** Multi-omics integration: Combining genomics, transcriptomics, proteomics, metabolomics for systems biology. **4.6** Applications: Stress biology, development, plant-microbe interactions, bio-prospecting, and functional trait analysis.	**10**	CO4	K2, K3, K4, K5, K6
Pedagogy:	Lectures, ICT based tools, Seminars, Assignments, case studies on plant systems biology			
Texts:	1. **António, C.** (2018) Plant Metabolomics- Methods and Protocols. Humana Press, UK 2. **Bernot, A.** (2004) Genome, Transcriptome and Proteome Analysis. John Wiley			

	3. **Cooper, G.M.** (2000) The Cell: A Molecular Approach, 2nd Edition. Sinauer, USA 4. **Karp, G.** (2009) Cell and Molecular Biology: Concepts and Experiments, 7th Edition. John Wiley & Sons, USA. 5. **Kramer, I.M.** (2015) Signal Transduction, 3rd Edition. University of Bordeaux, France. 6. **Lesk, A.M.** (2015) Introduction to Genomics. Oxford University Press, India 7. **Nelson, D.L., Cox, M.M., Lehninger, A.L.** (2013) Principles of Biochemistry, Freeman, New York. 8. **Primrose, S.B., Twyman, R.M.** (2006) Principles of Gene Manipulation and Genomics, Blackwell Publishing, Australia. 9. **Reece, R.J.** (2004) Analysis of Genes and Genomes, John Wiley & Sons Ltd. 10. **Saraswathy, N., Ramalingam, P.** (2011) Concepts and Techniques in Genomics and Proteomics, Biohealthcare Publishing. 11. **Segev, N.** (2009) Trafficking Inside Cells, Springer Science, USA. 12. **Sessa, G.** (2012) Molecular Plant Immunity, John Wiley & Sons, Israel. 13. **Voet, D., Voet, J.G., Pratt, C.W.** (2016) Fundamentals of Biochemistry, John Wiley & Sons, USA. 14. **Walker, J.M., Rapley, R.** (2008) Molecular Biomethods Handbook, UK. 15. **Wilson, K., Walker, J.** (2010) Principles and Techniques of Biochemistry and Molecular Biology, 7th Edition, Cambridge University Press.
References/ Readings:	1. **Chen, X., Li, Y., & Zhao, Q.** (2022) How 'omics technologies can drive plant engineering. Frontiers in Plant Science, 13, 927881. 2. **Gupta, N., Sharma, R., & Das, A.** (2025) Multi-omics approaches against abiotic and biotic stress. Plants, 14(6), 865. 3. **Kumar, S., & Sharma, A.** (2022) Multi-omics-based discovery of plant signaling molecules. Frontiers in Plant Science, 13, 877791. 4. **Li, X., Zhang, Y., & Wang, J.** (2022) Recent advancements in OMICS approaches to enhance plant productivity. Frontiers in Plant Science, 13, 952759. 5. **Ma, Y., Xu, J., & Li, H.** (2020) A multi-omics approach to solving problems in plant disease ecology. Frontiers in Microbiology, 11, 589432. 6. **Singh, R., Kumar, P., & Verma, S.** (2025) Climate-resilient crops: Integrating AI, multi-omics, and advanced phenotyping. Plants, 14(17), 2699.

	7. **Zhang, L., Chen, H., & Li, M.** (2024) Multi-omics research accelerates the clarification of the molecular mechanisms of leaf color variation in tea plants. Plants, 13(3), 426.
Web Resources:	1. https://academic.oup.com/bioinformatics/article/40/3/btae132/7623091 2. https://bigomics.ch/omics-playground/ 3. https://github.com/abbvie-external/OmicNavigator

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Title of the Course	Mycorrhizal Biotechnology
Course Code	BOT-6006
Number of Credits	3
Theory/Practical	Theory
Level	500
Effective from AY	2026-27
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	Yes

Pre-requisites for the Course:	Students should have undergone 400 level courses.	
Course Objectives:	To familiarize the students with various aspects of mycorrhizal fungi, study techniques and know their applications.	
Course Outcomes:	Students will be able to:	**Mapped to PSO**
	CO 1. Understand and describe the different types of biofertilizers and their characteristics, explore the various types of mycorrhizae and their classification, and to critically analyse the anatomy of ecto- and endo-mycorrhizas.	PSO1, PSO2
	CO 2. Develop skills in knowing the various AM fungal techniques. Understand and develop skills for producing mycorrhizal inoculation and inoculation procedures.	PSO1, PSO3, PSO4
	CO 3. Interpret and analyse the role of AM symbiosis in P transport, and the ecological factors affecting AM fungi.	PSO1, PSO2, PSO4
	CO 4. Understand and compare the role of phytohormones in AM symbiosis and analyse the role	PSO1, PSO2, PSO3

	of AM fungi in phytoremediation.			
	CO 5. Understand and apply mycorrhizal technology in sustainable agriculture, forestry, horticulture, and in photoremediation. Evaluate the role of mycorrhizae in climate change and in precision agriculture.		PSO3, PSO4	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	**Biofertilizers**: definition, types, characteristic features, their role and importance in sustainable agriculture. Introduction to mycorrhiza: definition and historical perspective; the symbiosis, evolutionary significance, types of mycorrhizae - ecto-mycorrhizae and endo-mycorrhizae, functional roles and ecological importance in nutrient uptake, water relations, soil structure, plant health, stress tolerance, and plant community interactions. Morphology and anatomy: anatomy of ecto-mycorrhizae - mantle, Hartig net, extra-metrical mycelium, root morphology; anatomy of endo-mycorrhizae - extra- and intra-radicle hyphae, entry point, arbuscules, vesicles, auxiliary cells; anatomy of other endo-mycorrhizal subtypes.	**13**	CO 1, CO 2, CO 3	K1, K2, K4
Module 2:	**Mycorrhizal techniques:** field and laboratory techniques – collection, isolation, and pure culturing of ecto-mycorrhizae; sampling, isolation, and pure culturing (including *in vitro*) of AM fungi; criteria for identification of AM fungi - generic and specific level; identification of commonly available AM fungal species; staining techniques; commercial production of AM inoculum; types of ecto-mycorrhizal inoculum, production of ecto-mycorrhizal fungal inoculum and inoculation procedures.	**06**	CO1, CO2	K1, K2, K3, K6,
Module 3:	**Physiology and metabolic process:** nutrient uptake and exchange; phosphate transport and role of AM fungi, developmental stages during mycorrhiza formation, pathways in P uptake; sources of P, C: N ratio; P uptake from the environment; N and C metabolism; water uptake - enhancing water relations, mycorrhiza-induced changes in stomata conductance, chlorophyll content and water potential; stress tolerance – biotic (pathogens and herbivores) and abiotic stress (drought, heavy metals and salinity); molecular and hormonal regulation - gene expression, hormonal balance, signalling molecules, mycorrhizae-induced resistance.	**11**	CO3, CO4	K1, K2, K3, K4

	Ecology and diversity: host specificity, community responses to environmental gradients, role in plant community dynamics, nutrient exchange mechanisms, physiological benefits, role in soil ecology - soil structure, nutrient cycling, multi-trophic interactions; influence on plant communities; effects on AM fungi - disturbance, agrochemicals and grazing.			
Module 4:	**Phytohormones and AM symbiosis:** role of cytokinins, gibberellins, ethylene, Abscisic acid (ABA), auxins, salicylic acid, jasmonic acid and jasmonates. Mycorrhizal applications in sustainable agriculture, forestry and horticulture. Phytoremediation - definition, advantages and limitations, contaminated and uncontaminated soils, heavy metals and their effects in plants, heavy metal detoxification mechanisms in plants and AM fungi, phytostabilization and phytoextraction, glomalin and its role. Future directions and current research: impact of climatic change-patterns, rising CO_2 levels; interaction with other soil microbes; emerging technologies – precision agriculture and targeted application of mycorrhizal fungi.	**15**	CO4, CO5	K2, K3, K4, K5, K6
Pedagogy:	Lectures/Assignments/Tutorials//ICT-tools/Seminars/Group discussions			
Texts:	1. Allen, M. F. (1991) The Ecology of Mycorrhizae. Cambridge University Press, UK. Pp. 184. 2. Arora, S. (2022) Innovations in Environmental Biotechnology. Springer Verlag, Singapore. Pp. 950. 3. Bitterlich, M., Mercy, L., et al., (2021) Instant insights: Arbuscular mycorrhizal fungi. *Burleigh Dodds Science Publishing Ltd.* Pp. 136. 4. Blaszkowski, J. (2012) Glomeromycota. W. Szafer Institute of Botany, Polish Academy of Sciences, Krakow, Pp 297. 5. Ferrol, N. & Lanfranco, L. (2020) Arbuscular Mycorrhizal Fungi: Methods and Protocols. Springer. Pp. 257. 6. Hamel, C. (2008) Mycorrhizae in Crop Production. CRC Press. Pp. 344. 7. Martin, F. (2016) Molecular Mycorrhizal Symbiosis. Wiley Blackwell. Pp. 528. 8. Prakash, A, & Mehrotra, V. S. (2006) Mycorrhiza. Scientific Publishers, Jodhpur. Pp. 320. 9. Read, D. J. (1996) Mycorrhizas in Ecosystems. CAB International. Pp. 448. 10. Smith, S. E. & Read, D. J. (2008) Mycorrhizal symbiosis. 3rd Edition, Elsevier, Amsterdam. Pp. 787. 11. Tiwari, M. & Sati, S. C. (2008) The Mycorrhizae: Diversity, Ecology and Applications. Daya Publishing House, New Delhi. Pp. 359.			

	12. Varma, A. & Hock, B. (1999) Mycorrhiza: Structure, Function, Molecular Biology and Biotechnology. 2nd edition. Springer. Pp. 704. 13. Varma, A., Tuteja N. & Prasad, R. (2018) Mycorrhiza - Nutrient Uptake, Biocontrol, Ecorestoration. Springer. Pp. 533. 14. Wu, Q. (2017) Arbuscular Mycorrhizas and Stress Tolerance of Plants. Springer. Pp. 327.
References/ Readings:	1. Bacon, C. W. & White, J. H. (2000) Microbial Endophytes Marcel Dekker, New York. Pp. 502. 2. Dwivedi, B. K. & Pandey, G. (1994) Biotechnology in India. Allahabad: Bioved Research Society. Pp. 241. 3. Satyanarayana, T., Deshmukh, S. K., & Deshpande, M. V. (2021) Progress in Mycology. Springer Singapore. Pp. 675. 4. Schenck, N. C. (1982) Methods and principles of mycorrhizal research. St. Paul Minnesota. Pp. 244. 5. Schenck, N.C. & Perez, Y. (1990) Manual for the identification of VA mycorrhizal fungi. International Culture Collection of VA Mycorrhizal Fungi. Synergistic Publications, Gainesville, Florida, USA. Pp. 286. 6. Sylvia, D. M., et al. (1987) Mycorrhizae in the next Decade, Practical Applications and Research Priorities. University of Florida. Gainesville, Florida. Pp. 364.
Web Resources:	Mycology and Mycorrhiza Journals may be referred.

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Title of the Course	Lab in Mycorrhizal Biotechnology.
Course Code	BOT-6007
Number of Credits	1
Theory/Practical	Practical
Level	500
Effective from AY	2026-27
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	Yes

Pre-requisites for the Course:	Students should have undergone 400 level courses.	
Course Objectives:	To familiarize the students with various aspects of mycorrhizal fungi, hands-on training in various techniques and know their applications.	
Course Outcomes:	Students will be able to:	**Mapped to PSO**
	CO 1. Understand the techniques for isolating AM fungal spores from rhizosphere and estimate the AM fungal spore density.	PSO1, PSO3
	CO 2. Identify commonly occurring AM fungal species based on spore morphology.	PSO1, PSO2, PSO3
	CO 3. Demonstrate and apply the *in vitro* culture technique for mass multiplication of AM fungi.	PSO3, PSO4
	CO 4. Evaluate and analyse the different staining techniques including histochemical staining for polyphosphate granules in AM fungal hyphae using toluidine blue O (TBO) and staining for lipid bodies in AM fungal hyphae and vesicles using sudan black.	PSO3

	CO 5. Develop skills for preparation of AM fungal inocula: trap and pure cultures.		PSO3, PSO4	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	**1.1** Isolation of AM fungal spores from rhizosphere soil. **1.2.** Sucrose density gradient centrifugation method for isolation of AM fungal spores. **1.3.** Estimation of AM fungal spore numbers. **1.4.** Techniques of staining roots for AM colonization. **1.5.** Histochemical staining for polyphosphate granules in AM fungal hyphae using toluidine blue O (TBO). **1.6.** Histochemical staining for lipid bodies in AM fungal hyphae and vesicles using sudan Black. **1.7.** Preparation of trap cultures. **1.8.** Preparation of pure cultures. **1.9.** Identification of some commonly occurring AM fungal species based on spore morphology. **1.10.** *In vitro* culture of AM fungi.	**30**	CO 1, CO 2, CO 3, CO 4, CO 5	K1, K2, K3, K4, K5
Pedagogy:	Hands on practicals/Tutorials/Field observations			
Texts:	1. Allen, M. F. (1991) The Ecology of Mycorrhizae. Cambridge University Press, UK. Pp. 184. 2. Arora, S. (2022) Innovations in Environmental Biotechnology. Springer Verlag, Singapore. Pp. 950. 3. Bitterlich, M., Mercy, L., et al., (2021) Instant insights: Arbuscular mycorrhizal fungi. *Burleigh Dodds Science Publishing Ltd.* Pp. 136. 4. Blaszkowski, J. (2012) Glomeromycota. W. Szafer Institute of Botany, Polish Academy of Sciences, Krakow, pp. 297. 5. Ferrol, N., & Lanfranco, L. (2020) Arbuscular Mycorrhizal Fungi: Methods and Protocols. Springer. Pp. 257. 6. Hamel, C. (2008) Mycorrhizae in Crop Production. CRC Press. Pp. 344. 7. Martin, F. (2016) Molecular Mycorrhizal Symbiosis. Wiley Blackwell. Pp. 528. 8. Prakash, A., & Mehrotra, V. S. (2006) Mycorrhiza. Scientific Publishers, Jodhpur. Pp. 320. 9. Read, D. J., *et al.* (1996). Mycorrhizas in Ecosystems. CAB International. Pp. 448. 10. Smith, S. E., & Read, D. J. (2008) Mycorrhizal symbiosis. 3rd Edition, Elsevier, Amsterdam. Pp. 787.			

	11. Tiwari, M. & Sati, S. C. (2008) The Mycorrhizae: Diversity, Ecology and Applications. Daya Publishing House, New Delhi. Pp. 359. 12. Varma, A. & Hock, B. (1999) Mycorrhiza: Structure, Function, Molecular Biology and Biotechnology. 2nd edition. Springer. Pp. 704. 13. Varma, A., Tuteja, N., & Prasad, R. (2018) Mycorrhiza - Nutrient Uptake, Biocontrol, Ecorestoration. Springer. Pp. 533. 14. Wu, Q. (2017) Arbuscular Mycorrhizas and Stress Tolerance of Plants. Springer. Pp. 327.
References/ Readings:	1. Bacon, C. W. & White, J. H. (2000) Microbial Endophytes Marcel Dekker, New York. Pp. 502. 2. Dwivedi, B. K. & Pandey, G. (1994) Biotechnology in India. Allahabad: Bioved Research Society. Pp. 241. 3. Satyanarayana, T., Deshmukh, S. K., & Deshpande, M. V. (2021) Progress in Mycology. Springer Singapore. Pp. 675. 4. Schenck, N. C. (1982) Methods and principles of mycorrhizal research. St. Paul Minnesota. Pp. 244. 5. Schenck, N.C. & Perez, Y. (1990) Manual for the identification of VA mycorrhizal fungi. International Culture Collection of VA Mycorrhizal Fungi. Synergistic Publications, Gainesville, Florida, USA. Pp. 286. 6. Sylvia, D. M., et al. (1987) Mycorrhizae in the next Decade, Practical Applications and Research Priorities. University of Florida. Gainesville, Florida. Pp. 364.
Web Resources:	Mycology and Mycorrhiza Journals may be referred.

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Title of the Course	Algal Biotechnology
Course Code	BOT-6008
Number of Credits	3
Theory/Practical	Theory
Level	500
Effective from AY	2026-27
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	Yes

Pre-requisites for the Course:	Students should have undergone 400 level courses.	
Course Objectives:	• Equip students with knowledge and skills related to the biology and cultivation of algae. • Impart knowledge and skills on metabolic potential, and biotechnological applications of algae for sustainable industrial, agricultural and environmental solutions.	
Course Outcomes:	Students will be able to:	**Mapped to PSO**
	CO 1. Understand the algal cultivation methods, including growth optimization.	PSO 1, PSO 3
	CO 2. Analyze the biochemical composition of algae and its relevance to industrial applications.	PSO 3, PSO 4
	CO 3. Evaluate the role of algae in biofuel production, wastewater treatment, and carbon sequestration.	PSO 3, PSO 4
	CO 4. Assess the commercial, agricultural and environmental potential of algal biotechnology in addressing global challenges.	PSO 3, PSO 4

Content:		No of hours	Mapped to CO	Cognitive Level
Module 1:	**1.1. Algal Biotechnology:** Scope and significance of algal biotechnology; History and development of algal research, Major algal groups used in biotechnology. **1.2.** Microalgal Cultivation and Biomass Production: Collection, isolation, and maintenance of pure cultures; Algal growth media and culture techniques: batch, continuous, photobioreactors; Factors affecting algal growth such as light, CO_2, nutrients, temperature, salinity; Scale-up of algal cultivation; Harvesting and drying methods. **1.3. Seaweed cultivation:** Seaweed resources and their distribution; Promotion of seaweeds in India, cultivation and value chain in India. Seedling production of *Gracilaria* and *Ulva*. **1.4. Mariculture:** Scientific basis and Techniques of Mariculture: *Eucheuma*, *Porphyra,* and *Laminaria* technique. Rafts used in Mariculture. **1.5. Algae in Food:** *Porphyra* as food: Cultivation and economics. *Spirulina* as human food: Nutritional, economic and environmental aspects. Microalgal nutraceuticals, and their production; Cultivated edible kelps: Edible products from kelp and production methods. Public health aspects of microalgal products. Microbial contamination, Extraneous materials, metals, organic compounds.	**15**	CO 1, CO 2, CO 3, CO 4	K1, K2, K3, K4
Module II	**2.1.** Algae in Environment: Phycoremediation: Role of physico-chemical parameters on growth and development of algae; Algal survival under physical and chemical stresses; Responses of algae to pollutants and heavy metal pollution; Uptake and accumulation of xenobiotic substances; Utilization of algae in pollution control; Effluent treatment using algae; Algal biomass and its utilization. Algal consortia in bioremediation. Algal bioindicators of pollution; Carbon capture and sequestration using algae. **2.2. Algae in Agriculture:** Biofertilizers: Free-living cyanobacteria and algalization, Microalgal soil conditioners, Microalgal plant growth regulation, biocontrol agents; Biopesticides. Use of seaweeds in agriculture and horticulture.	**15**	CO 2, CO 3, CO 4	K1, K2, K3, K4

	2.3. Algae as a Source of Biomolecules: Nutraceuticals: vitamins, antioxidants, pigments (β-carotene, astaxanthin, phycobiliproteins); proteins, amino acids, polysaccharides, and lipids from algae; bioactive compounds with antibacterial, antifungal, and antiviral activities; extraction and purification methods; commercial algal products in the market. Commercial products from algae: Hydrocolloids: Chemistry, production, and Application, future aspects of alginates, Carrageenans, Agars. **2.4. Algae for Bioenergy:** Biofuels from algae: biodiesel, bioethanol, biogas; lipid accumulation and metabolic engineering of algae for energy; production of fatty acids (PUFA); genetic engineering approaches in algal bioenergy; challenges in commercialisation of algal biofuels. Lipids, Polyols, tri-glycerol and hydrocarbon from microalgae. Hydrogen production by algae: Water splitting role of algae in hydrogen production, Bio-photolysis of water.			
Module 3:	**3.1. Ecological significance of Algae:** Marine dinoflagellates blooms: Dynamics and impacts; Blooms dynamics: Initiation, growth, maintenance, Termination, Ecological and Economic impacts: Negative and Positive impacts. Harmful algal blooms in India. Hazards of freshwater blue-green algae*:* Neurotoxins, Hepatotoxins, other toxins, Medicinal aspects; Human poisoning, contact dermatitis. Marine biofouling*:* Bacterial, Microalgal, and Macroalgal biofouling, control treatments; antifouling coatings. Biological control, Non-adhesive surfaces. **3.2. Fossil algae:** Diatomite-industrial mineral, Calcareous algal fossils and their products, algal kerogen in petroleum and coal. **3.3. Algae in space:** Algae and life support systems; Algae and planetary biology, Future of algae in space. Algal Transgenics and Biotechnology. **3.4.** Recent Advances and Applications: Algal nanotechnology; Algae in cosmetics and pharmaceuticals; Bioplastics from algae. Algal toxins and their impacts; Future perspectives and sustainable development goals. Major algal-based companies in the world, Algal based commercial products in the market, Algal research laboratories across the globe; Use of synthetic biology in the manufacture of by-products from Algae.	**15**	CO 2, CO 3, CO 4	K1, K2, K3, K4
Pedagogy:	Lectures/Tutorials/ICT tools/Assignments/Seminars.			

Textbooks:	1. **Ahmad, A., & Ashraf, S. S.** (2025) *Algae biotechnology for biomedical and nutritional applications.* Elsevier. 2. **Almeida, C. M. R., & Silva, A. M. T.** (2023) *Biotechnology applications of microalgae. MDPI.* 3. **Bux, F.** (2016) *Algae biotechnology: Products and processes.* CRC Press. 4. **Karaca, H. & Koyunoğlu, C.** (2022) *Algal biotechnology for fuel applications.* Bentham Science Publishers. 5. **Richmond, A., & Hu, Q.** (2013) *Handbook of microalgal culture: Applied phycology and biotechnology* (2nd ed.). Wiley-Blackwell. *Algae biotechnology: Products and processes.*
References/ Readings:	1. **Chojnacka, K., Wieczorek, P. P., Schroeder, G., & Michalak, I.** (2018) *Algae biomass: Characteristics and applications: Towards algae-based products.* Springer. 2. **Kumar, L., Bharadvaja, N., D. Kumar, & Anand, R.** (2025) *Algae-derived biochemicals of industrial importance,* Springer. 3. **Sahu, N., & Sridhar, S.** (2024a) *Algal biotechnology: Applications for industrial development and human welfare.* CRC Press. 4. **Sahu, N., & Sridhar, S.** (2024b) *Algal Biotechnology: Current trends, challenges and future prospects for a sustainable environment.* CRC Press. 5. **Singh, Y., Khattar, J. I. S., Singh, D. P., & Singh, R. P**. (2025) *Industrial and biotechnological applications of algae.* Springer. 6. **Thangadurai, D., Sangeetha, J., Elumalai, S., & Chandrabanda Thimmappa, S**. (2021) *Phycobiotechnology: Biodiversity and biotechnology of algae and algal products for food, feed, and fuel.* Apple Academic Press. 7. **Zhang, X., & Wang, L.** (2023) *Marine microalgae and their industrial biotechnological applications.* Springer.
Web Resources:	1. https://dokumen.pub/applied-algal-biotechnology 2. https://www.researchgate.net/publication/318449035_Algae_Biotechnology 3. https://www.sciencedirect.com/book/9780323904766/algal-biotechnology 4. https://www.scribd.com/document/722433415/Algae-in-Biotechnology 5. https://link.springer.com/book 6. https://www.researchgate.net/publication/359231554_Progressive_Algal_Biotechnology_A_Sustainable_and_Viable_Approach_towards_Bioeconomy

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Title of the Course	Lab in Algal Biotechnology
Course Code	BOT-6009
Number of Credits	1
Theory/Practical	Practical
Level	500
Effective from AY	2026-27
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	Yes

Pre-requisites for the Course:	Students should have undergone 400 level courses.	
Course Objectives:	• Provide hands-on training in the isolation, culture, and maintenance of pure algal culture. • Train students in experimental approaches for studying algal applications in biofertilizers, biofuels, nutraceuticals, and wastewater treatment. • Inculcate research-oriented thinking through the design and execution of algal biotechnology experiments.	
Course Outcomes:	Students will be able to:	**Mapped to PSO**
	CO 1. Demonstrate skills in isolation, culturing, and maintenance of pure algal strains under laboratory conditions.	PSO 3
	CO 2. Analyze growth parameters and biochemical constituents of algal biomass using appropriate quantitative methods.	PSO 1, PSO 3

	CO 3. Apply algal biotechnology techniques in biofertilizer production, phycoremediation, and biofuel research.		PSO 3, PSO 4	
	CO 4. Extract and evaluate commercially important algal products such as pigments, proteins, and polysaccharides.		PSO 3, PSO 4	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	**1.1.** Collection and preservation of freshwater and marine algae from natural habitats. **1.2.** Morphological observation and identification of common algal genera (microalgae and macroalgae). **1.3.** Isolation of pure microalgal strains by streak plate methods. **1.4.** Culture of algae using BG-11 and ASN-III culture media and maintenance of cultures. **1.5.** Microscopic examination of filamentous algae using iodine, safranin, and neutral red for cell structure and reserve food materials. **1.6.** Determination of algal growth and measurement of growth curve under controlled conditions. **1.7.** Preparation of cyanobacterial biofertilizer using various formulations. **1.8.** Estimation of growth of crop plants with treatment of cyanobacterial biofertilizers. **1.9.** Extraction and estimation of lipids from microalgae for biofuel studies. **1.10.** Extraction and estimation of proteins from algal biomass. **1.11.** Extraction and estimation of carbohydrates from algal biomass. **1.12.** Extraction of photosynthetic pigments from algae (chlorophyll, carotenoids, phycobilins). **1.13.** Isolation of agar/alginate from red and brown algae.	**30**	CO1, CO2, CO3, CO4	K1, K2, K3, K4
Pedagogy:	Hands-on practicals/Demonstrations.			
Texts:	1. **Andersen, R. A.** (2005) *Algal culturing techniques*. Academic Press. 2. **Galanakis, C. M.** (2020) Microalgae: Cultivation, Recovery of Compounds and applications. Academic Press U.K.			

	3. **Lee, R. E.** (2018) *Phycology* (5th ed.). Cambridge University Press. 4. **Lewin, R. A.** (2008) *Algae: Anatomy, biochemistry, and biotechnology* (2nd ed.). CRC Press. 5. **Richmond, A., & Hu, Q.** (Eds.). (2013) *Handbook of microalgal culture: Applied phycology and biotechnology (*2nd ed.). Wiley-Blackwell. 6. **Singh, S. P., & Singh, P.** (2014) *Microalgal biotechnology: Potential and production. Springer.*
References/ Readings:	1. **Alexander, M.** (1999) Biodegradation and Bioremediation. Academic Press. 2. **Ayhan, Demirbas**. (2008) Biofuels: Securing the Planet's Future Energy Needs. Springer – Verlag London Limited. *3.* **Borowitzka, M. A., & Beardall, J.** (2016) *Algae: An introduction to phycology*. Cambridge University Press. *4.* **Borowitzka, M. A., & Moheimani, N. R.** (2013) *Algae for biofuels and energy*. Springer. 5. **Craig, A. Grimes., & Oomman** (2008) Light, water, hydrogen: the solar generation of hydrogen by water. Springer Science + Business Media, L.L.C. 6. **David, M. Mousdale.** (2008) Biofuels: biotechnology, chemistry, and sustainable development. Taylor & Francis Group, L.L.C. 7. **Hasanuzzaman, M. & VaraPrasad, M. N.** (2020) Handbook of Bioremediation. Physiological, Molecular and Biotechnological Interventions. Springer. 8. **Kevin, G. Sellner.** (2009) Physiology, Ecology, and Toxic Properties of Marine Cyanobacteria Blooms. American Society of Limnology and Oceanography Press. 9. **Graham, L. E., James, M., Graham. & Wilcox, L.W.** (2009) Algae. Benjamin Cummings. 10. **Singh, A. & Ward, O. P.** (2004) Applied Bioremediation and Phytoremediation. Springer. 11. **Stengel, D. B., & Connan, S.** (2015) Marine algae: A source of biomass for biotechnological applications. Humana Press, New York. 12. **SubbaRao, N. S.** (2000) Cyanobacterial biofertilizers. Science Publishers. 13. **Tiwari, B. K., & Declan, J. Troy. (**2015) Seaweed Sustainability Food and Non-food products Ed, Academic Press Elsevier.
Web Resources:	1. https://uomustansiriyah.edu.iq/media/lectures/6/6_2020_06_11%2102_31_26_AM.pdf 2. https://www.springer.com/series/7591 3. https://www.tandfonline.com/journals/tapy20 4. https://en.wikipedia.org/wiki/Journal_of_Phycology

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Title of the Course	Plant Stress Physiology
Course Code	BOT-6010
Number of Credits	4
Theory/Practical	Theory
Level	500
Effective from AY	2026-27
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	Yes

Pre-requisites for the Course:	Students should have undergone 400 level courses.	
Course Objectives:	• Understand the physiological and biochemical responses of plants under various abiotic and biotic stresses. • Study the mechanisms of stress perception, signal transduction, and tolerance in plants. • Develop skills in experimental approaches for assessing plant stress and designing mitigation strategies.	
Course Outcomes:	Students will be able to:	**Mapped to PSO**
	CO 1. Explain the types and sources of abiotic and biotic stresses affecting plant growth and productivity.	PSO1, PSO 2
	CO 2. Describe the physiological and biochemical responses of plants under stress conditions.	PSO 1, PSO2
	CO 3. Evaluate the mechanisms of tolerance and resistance to environmental stresses at cellular and molecular levels.	PSO 2

	CO 4. Apply knowledge of plant stress responses in developing strategies for improving crop stress tolerance.		PSO 2, PSO 4	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	**1.1.** Plant Stress Physiology: Types of plant stress: Abiotic and biotic stress: Classification: primary vs. secondary stresses, chronic vs. acute. Importance of studying plant stress physiology; Stress and crop productivity. **1.2.** Abiotic Stress: Causes and effect of drought stress, salinity stress, temperature stress (heat and cold), light stress (excess and deficiency), heavy metal toxicity, nutrient stress, submergence stress. **1.3.** Biotic Stress: Viruses, bacteria, fungi, insect pests and herbivory; Plant defense mechanisms.	**15**	**CO 1, CO 2**	**K1, K2, K3**
Module 2:	**2.1.** Physiological and Biochemical Responses to Stress: Water relations and osmotic adjustment; Photosynthesis under stress; Respiration changes during stress; Stress-induced oxidative damage and Reactive Oxygen Species (ROS), Membrane stability and lipid peroxidation; Antioxidant defense mechanisms. **2.2.** Adaptation and Acclimation Mechanisms: Morphological and anatomical adaptations; Physiological and biochemical acclimation; Role of compatible solutes (proline, glycine betaine, sugars); heat shock proteins and chaperones.	**15**	**CO 2, CO 3**	**K1, K2, K3**
Module 3:	**3.1.** Molecular Mechanisms of Stress Tolerance: Signal perception and transduction pathways; Stress-responsive gene expression; Role of phytohormones (abscisic acid, ethylene, salicylic acid, jasmonic acid); Molecular breeding and genetic engineering for stress tolerance. **3.2.** Stress Management and Mitigation: Agronomic practices to reduce stress effects; Growth regulators and biostimulants; Soil and water management; Application of molecular tools in stress management.	**15**	**CO 2, CO 3**	**K1, K2, K3**

Module 4:	**4.1.** Experimental Techniques and Applications: Methods to study plant stress (drought simulation, salinity treatment); Physiological assays (chlorophyll fluorescence, gas exchange measurements); Biochemical assays (antioxidant enzyme activity, osmolyte estimation); Molecular techniques (qPCR, transcriptomics). 4.2. Recent Advances and Case Studies: Genomic and proteomic approaches; Nanotechnology; CRISPR and gene editing for stress tolerance; Case studies on major crops related to stress (rice and wheat).	**15**	**CO 2, CO 3, CO 4**	**K1, K2, K3, k4**
Pedagogy:	Lectures/Tutorials/Group Discussions/ICT tools/Assignments/Seminars.			
Texts:	1. **Bhatla, S. C., & Lal, M. A. (2023)** Plant physiology, development and metabolism. 2nd ed. Springer Nature. 2. **Gupta, D. K. (2021)** Plant growth and stress physiology: Plant in challenging environments. Springer. 3. **Rao, K. V. M., Raghavendra, A. S., & Janardhan Reddy, K. (2010)** Physiology and molecular biology of stress tolerance in plants. Springer. 4. **Vaishnav, A., & Gupta, D. K. (2021)** Plant stress mitigators: Action and application. Springer Nature.			
References/ Readings:	1. **Shabala, S.** (2017) Plant stress physiology (2nd ed.). CABI. 2. **Shabala, S.** (2012) Plant stress physiology. (1st ed). CABI. 3. **Gupta, U. S.** (2004) Physiology of stressed crops, Volume 1: Hormone relations. CRC Press. 4. **Gupta, U. S.** (2005) Physiology of stressed crops, Volume 5: Membrane system. CRC Press. 5. **Alexou, M.** (2023) Plant stress physiology and climate change: How plants struggle in our new world. Cambridge Scholars Publishing. 6. **Hasanuzzaman, M., & Nahar, K.** (2023) Plant stress physiology. IntechOpen. 7. **Kumar, P., & Bharati, P. K.** (2021) Plant physiology: Stress, diseases and management. Discovery Publishing House.			
Web Resources:	1. https://www.yakibooki.com/download/plant-stress-physiology-2nd-edition 2. https://www.icar-crida.res.in/assets/img/Books/2011-12/Abiotic_Stress_in_Plants_-_Mechanisms_and_Adaptations_2011.pdf 3. https://core.ac.uk/download/478132305.pdf 4. https://www.researchgate.net/publication/393924754_PLANT-STRESS-PHYSIOLOGY-DAYS-SCIENTIFIC-BOOKLET			

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Title of the Course	Plant Eco-physiology and Wetland Biotic Interactions
Course Code	BOT-6011
Number of Credits	4
Theory/Practical	Theory
Level	500
Effective from AY	2026-27
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	Yes

Pre-requisites for the Course:	Students who have undergone 400-level courses	
Course Objectives:	• Understand and analyze plant eco-physiology, functional adaptations, and ecological mechanisms in diverse ecosystems, with emphasis on wetland plants and their interactions with microbes and other biotic components. • Integrate knowledge of eco-physiology, biotic interactions, and ecosystem services to evaluate and propose strategies for sustainable use, conservation, and bioprospecting of wetland biodiversity.	
Course Outcomes:	Students will be able to:	**Mapped to PSO**
	CO 1. Explain the principles of plant eco-physiology and adaptive strategies in natural and wetland ecosystems.	PSO 1
	CO 2. Analyze plant-microbe-soil and plant-animal interactions shaping wetland ecosystem function and stability.	PSO 2

	CO 3. Evaluate wetland ecosystem services, conservation approaches, and the bioprospecting potential of wetland flora and microbes.		PSO 4	
	CO 4. Integrate eco-physiological and biochemical insights to develop sustainable plant-based solutions in the context of therapeutics, climate adaptation, and green technology.		PSO 3, PSO 4	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	**Foundations of Plant Eco-physiology** **1.1.** Principles and scope of plant eco-physiology: integration of ecological and physiological processes, energy flow, and resource allocation. **1.2.** Environmental modulation of photosynthesis and respiration: light, temperature, and nutrient effects on carbon balance. **1.3.** Carbon and nutrient partitioning: source–sink dynamics and ecological implications. **1.4.** Role of mineral nutrition, water relations, and phytohormones (auxins, cytokinins, gibberellins, ABA, ethylene, brassinosteroids) in plant performance across habitats. **1.5.** Assessment tools in eco-physiology: gas exchange, chlorophyll fluorescence, water potential and metabolic markers.	**15**	CO 1, CO 4	K2, K3, K4
Module 2:	**Wetland Plant Adaptations and Functional Ecology** **2.1.** Wetland types and plant diversity: Myristica swamps, mangroves, marshes, and peatlands. **2.2.** Eco-physiological adaptations to flooding, anoxia, and salinity: morphological (pneumatophores, stilt roots, knee roots, aerenchyma), anatomical, and biochemical mechanisms. **2.3.** Nutrient and carbon cycling in wetlands: productivity and decomposition dynamics. **2.4.** Role of phytohormones and phytoestrogens in wetland plant adaptation and reproductive ecology. **2.5.** Environmental stress and resilience: pollution, eutrophication, and microplastic exposure.	**15**	CO 1, CO 2, CO 4	K3, K4

Module 3:	**Plant–Microbe–Biotic Networks in Wetlands** **3.1.** Microbial diversity in wetlands: endophytes, rhizosphere microbes, and mycorrhizae. **3.2.** Functional roles in nutrient acquisition, stress mitigation, and hormone modulation. **3.3.** Biotic interactions: mutualism, antagonism, herbivory, and defence strategies (secondary metabolites, inducible responses). **3.4.** Network ecology of wetland systems: trophic interactions, ant–plant–fungal symbioses, nestedness, robustness. **3.5.** Case studies: Myristica swamp microbiome, mangrove–endophyte symbiosis, and algal–plant–fungal partnerships.	**15**	CO 2, CO 3, CO 4,	K3, K4, K6
Module 4:	**Ecosystem Services, Conservation, and Bioprospecting** **4.1.** Ecosystem services of wetlands: biodiversity, carbon sequestration, nutrient buffering, and hydrological balance. **4.2.** Wetland degradation and restoration: land-use change, pollution, and climate adaptation strategies. **4.3.** Bioprospecting potential: phytochemicals, phytoestrogens, antioxidants, and antimicrobial metabolites from plants and endophytes. **4.4.** Linking eco-physiology to applied domains: therapeutics, bioactives, green nanotechnology. **4.5.** Policy and innovation: Ramsar Convention, TKDL, IPR, and AI-based biodiversity monitoring.	**15**	CO 3, CO 4	K5, K6
Pedagogy:	Lectures/Concept-based Assignments/Critical Reading/Peer Discussions/ Seminars/Field visits.			
Texts:	1. **Dhal, P. B., Devi, R. S., Bhadouria, R., & Tripathi, S.** (2023) Phytohormones: Role in Ecophysiological Responses of Tropical Plants to Varying Resource Availability. In Ecophysiology of Tropical Plants (pp. 265-283). CRC Press. 2. **Hasanuzzaman, M. (Ed.).** (2020) Plant ecophysiology and adaptation under climate change: mechanisms and perspectives I: general consequences and plant responses. Springer Nature. 3. **Hopkins, W. G., & Hüner, N. P. A.** (2008) Introduction to Plant Physiology (4th ed.). Wiley-Blackwell, USA. 4. **Fitter, A. H., & Hay, R. K. M.** (2012) Environmental Physiology of Plants (3rd ed.). Academic Press, UK. 5. **Fritz H. Schweingruber, Andrea Kučerová, Lubomír Adamec, Jiří Doležal** (2020) Anatomic Atlas of Aquatic and Wetland Plant Stems, Springer 6. **Lambers, H., Chapin III, F. S., & Pons, T. L.** (2008) Plant Physiological Ecology (2nd ed.). Springer, USA.			

	7. **Larcher, W.** (2003) Physiological Plant Ecology: Ecophysiology and Stress Physiology of Functional Groups (4th ed.). Springer, Germany. 8. **Mitsch, W. J., & Gosselink, J. G.** (2015) Wetlands (5th ed.). Wiley, USA. 9. **Parihar, P., Singh, S., Singh, R., & Tripathi, D. K.** (2016) Plant Responses to Environmental Stresses: From Fundamental to Molecular Approaches. Springer, India. 10. **Pugnaire, F. I., & Valladares, F.** (2007) Functional Plant Ecology (2nd ed.). CRC Press, USA. 11. **Sivasubramaniam, S.** (2011) Mangrove Ecosystems: A Global Biogeographic Perspective. CRC Press, USA. 12. **Taiz, L., Zeiger, E., Møller, I. M., & Murphy, A**. (2015) Plant Physiology and Development (6th ed.). Sinauer Associates, USA. 13. **Van der Valk, A. G. (Ed.).** (2012) The Biology of Freshwater Wetlands (2nd ed.). Oxford University Press, UK.
References/ Readings:	1. **Beena, Tewari. Fulara.** (2020) Ecophysiology and Ecotoxicology. Uttarakhand Open University, India. 2. **Crous, K. Y., Atkin, O. K., et al.** (2022) Temperature responses of photosynthesis and respiration in evergreen species across biomes. Frontiers in Plant Science. 3. **Guigard, L., Nazaret, F., Almario, J., Bertolla, F., Boubakri, H., Cantarel, A. A., & Shade, A.** (2025) The connections of climate change with microbial ecology and their consequences for ecosystem, human, and plant health. Journal of Applied Microbiology. 4. **Lumibao, C. Y., Harris, G., & Birnbaum, C.** (2024) Global diversity and distribution of rhizosphere and root-associated fungi in coastal wetlands: a systematic review. Estuaries and Coasts, *47*(4), 905-916. 5. **Mitsch, W. J., & Gosselink, J. G.** (2000) The value of wetlands: Importance of wetland ecosystems for biodiversity and conservation. BioScience, 50(2), 133-142. 6. **Sand-Jensen, K.** (1989) Environmental variables and their effect on photosynthesis in aquatic plants. Aquatic Botany, 35(1), 23-46. 7. **Shivaprakash, K. N., Rajanna, J. M., Gunaga, S. V., Ravikanth, G., Vasudeva, R., Shaanker, R. U., & Dayanandan, S.** (2022) The flooded habitat adaptation, niche differentiation, and evolution of Myristicaceae trees in the Western Ghats biodiversity hotspot in India. Biotropica, *54*(6), 1349-1362. 8. **Xu, Z., Zhou, G., & Shimizu, H.** (2015) Response and adaptation of photosynthesis, respiration, and antioxidant systems to elevated CO2 and environmental stress. *Frontiers in Plant Science*. 9. **Nandhini, M., Roopa, G., Kumudini, B. S., & Prakash, H. S.** (2025) Ecological Symphony: Multi-Omics Study of Environment Dynamics of Endophyte Communities. In Multi-omics Approach to Investigate Endophyte Diversity (pp. 265-286). Singapore: Springer Nature Singapore.
Web Resources:	1. https://uou.ac.in/sites/default/files/slm/ENSE-654.pdf

	2. https://uou.ac.in/sites/default/files/slm/MSCBOT-602.pdf 3. www.icar-crida.res.in/assets/img/Books/Abiotic%20and%20Biotic%20Stress%20in%20Plants_2016.pdf 4. https://www.khanacademy.org/science/hs-bio/x230b3ff252126bb6:energy-and-matter-in-biological-systems/x230b3ff252126bb6:photosynthesis/a/photosynthesis-and-the-environment 5. https://api.pageplace.de/preview/DT0400.9781482279993_A38593645/preview-9781482279993_A38593645.pdf 6. https://www.google.co.in/books/edition/Plant_Stress_Physiology/ImwtEAAAQBAJ?hl=en&gbpv=1&printsec=frontcover 7. https://pubhtml5.com/kfjv/huod/basic/

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Discipline Specific Vocational Elective (DSVE) Courses

Title of the Course	Ecotourism
Course Code	BOT-6401
Number of Credits	1 T+2 P
Theory/Practical	Theory/Practical
Level	500
Effective from AY	2026-27
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	Yes

Pre-requisites for the Course:	Students should have undergone 400-level courses.	
Course Objectives:	• Develop awareness and understanding of ecotourism principles, sustainable practices, and conservation of natural and cultural resources. • Enable students to assess, plan, and evaluate ecotourism programs, including their socio-economic and environmental impacts. • Impart practical skills and training in ecotourism-based goods, services, and digital communication platforms. • Prepare students for short-term internships, fostering hands-on experience in real-world ecotourism projects. • Create opportunities for self-employment and entrepreneurial initiatives in the ecotourism sector, particularly in Goa and the Western Ghats.	
Course Outcomes:	The student will be able to:	**Mapped to PSO**
	CO 1. Understand the concepts, principles, and terminology of tourism and ecotourism, including their history, components, and sociological relevance.	PSO 1, PSO 2

	CO 2. Identify and analyze ecotourism resources, biodiversity, and community-based practices, applying frameworks for planning, auditing, and capacity building toward sustainable tourism models.		PSO 2, PSO 4	
	CO 3. Apply creative, technical, and digital tools to design and manage ecotourism communication materials and platforms such as portfolios, videos, posters, blogs, and websites.		PSO 3, PSO 4	
	CO 4. Evaluate the socio-economic, livelihood, and conservation impacts of ecotourism through professional project proposals, internships, and reflective field-based learning.		PSO 2, PSO 4	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	**Theory:** **1.1. Principles, components and Characteristics of Ecotourism:** Historical development, concepts, impacts of tourism, stakeholders, sociology, responsible marketing, customer satisfaction, and relevance of ecotourism; environmental sustainability practices and conservation, and capacity building in ecotourism. **1.2. Ecotourism Terms**: Adventure tourism, certification, commercialization chain, cultural tourism, canopy walkway, conservation enterprises, ecosystem, ecotourism activities, ecotourism product, ecotourism resources, ecotourism services, endemism, ecolabelling, ecotourism "lite", Geotourism, greenwashing, stakeholders, sustainable development, sustainable tourism, linkages. **1.3. Ecotourism resources in Goa**: Bhagwan Mahaveer National Park and wildlife sanctuary, Bondla wildlife sanctuary, Cotigao wildlife sanctuary, Salim Ali bird sanctuary. Major ecosystems, vegetation types, biodiversity, and tourism areas in Goa. Ecotourism related festivals and events, entertainment overview, culture, famous destinations, sightseeing, historical monuments, museums, temples, national parks and wildlife sanctuaries, hill stations, waterfalls, rivers, lakes, beaches, islands, mangroves, backwaters, wildlife watching and bird watching sites, rural handicrafts, traditional healers, archeological sites, adventure sports, sacred groves, mountains, etc. **1.4. Forms of Ecotourism**: Eco regions, eco places, Western Ghats of Goa, Waterfalls in Goa, Eco travel: do's and don'ts, Eco trips. Potentials of ecotourism in Goa. Community-based ecotourism.	**15**	CO 1	K1, K2

	1.5. Ecotourism Planning and livelihood security: Strategies, design of activities, target groups, opportunities, capacity building, threats, expectations of positive and negative impacts, strengths and weaknesses, benefits and beneficiaries, stakeholders, linkages, economics, ecotourism auditing. Problems with ecotourism. Carrying capacity. Ecotourism facilities – Green report card. Ecotourism management – issues. Eco-development committees.			
Module 2:	**Practicals:** **2.1.** Familiarizing with Ecotourism websites and portals. **2.2.** Ecotourism films and documentaries - appreciation. **2.3.** Production of ecotourism photo portfolio. **2.4.** Production and display of original thematic video film of short duration. **2.5.** Creation of an ecotourism-themed blog or website. **2.6.** Creating artistic ecotourism promotional brochures, booklets, or posters. **2.7.** Submission of the ecotourism project proposal in a standard format. **2.8.** Field visit. **2.9.** Internship at assigned ecotourism facility **2.10.** Preparation of a basic ecotourism resource map (using Google Earth/QGIS/manual mapping) identifying biodiversity hotspots, community areas, buffer zones, and visitor routes. **2.11.** Calculation and estimation of ecological and social carrying capacity for a selected ecotourism site based on secondary data. **2.12.** Designing a structured format to evaluate environmental, socio-economic, and cultural impacts of an ecotourism destination. **2.13.** Identification and classification of stakeholders (local communities, forest department, tourists, NGOs, tour operators) and preparation of a stakeholder influence–interest matrix. **2.14.** Development of a sustainability audit checklist for an ecotourism facility (waste management, water use, energy use, biodiversity protection, local employment). **2.15.** SWOT Analysis of an Ecotourism Destination. **2.16.** Designing a Community-Based Ecotourism Model. **2.17.** Preparation of a Sustainable Ecotourism Itinerary. **2.18.** Policy and Case Study Review Presentation.	**60**	CO 3, CO 4	K4, K5, K6

Pedagogy:	Lectures / Tutorials / Videos / Group Discussions / Assignments / Mini Projects / Hands-On Training / Demonstrations / Portal & Blog Design / Photographic & Videography Sessions / Field Visits / Expert Lectures at Ecotourism Facility
Text Books:	1. **Baiquni, M., Damanik, J., & Rindrasih, E.** (2024) Ecotourism destination in archipelago countries. UGM Press. 2. **Buckley, R.** (2004) Environmental impacts of ecotourism. CABI Publishing. 3. **Fennell, D. A.** (2014) Ecotourism (4th ed.). Routledge. 4. **Fletcher, R.** (2014) Romancing the wild: Cultural dimensions of ecotourism. Duke University Press. 5. **France, R. L.** (2011) Environmental restoration and design for recreation and ecotourism. CRC Press. 6. **Goedkoop, M., & Spriensma, R.** (1995) The eco-indicator 95 (p. 85). PRé Consultants. 7. **Hill, J. L., & Gale, T. (Eds.).** (2009) Ecotourism and environmental sustainability: Principles and practice. Ashgate Publishing. 8. **Wearing, S., & Neil, J.** (2009) Ecotourism. Routledge. 9. **Wearing, S., & Schweinsberg, S.** (2018) Ecotourism: Transitioning to the 22nd century. Routledge. 10. **Zeppel, H.** (2006) Indigenous ecotourism: Sustainable development and management (Vol. 3). CABI.
References/ Readings:	1. **Fang, W. T., Hassan, A. A., & Horng, M.** (2024) Ecotourism attractions. In Ecotourism: Environment, health, and education (pp. 261–299). Springer Nature Singapore. 2. **Gale, T., & Hill, J.** (2016) Ecotourism and environmental sustainability: An introduction. In Ecotourism and environmental sustainability (pp. 3–16). Routledge. 3. **Hossain, M. S., Islam, M. S., et al.** (2025) Sustainable ecotourism in Bangladesh: A SWOT analysis of ecotourism destinations. International Journal of Multidisciplinary Research and Growth Evaluation, 6(2), 1146–1163. 4. **Ijeomah, H. M., & Okoli, C. I. C.** (2016) Challenges of ecotourism in selected destinations of Nigeria. International Journal of Agriculture and Rural Development, 19(2), 2655–2668. 5. **Kiss, A.** (2004) Is community-based ecotourism a good use of biodiversity conservation funds? A rigorous analysis of both social and ecological impacts of community-based ecotourism. Trends in Ecology & Evolution, 19, 5232–5237. 6. **Neth, B.** (2008) Ecotourism as a sustainable rural community development and natural resource management in Tonle Sap biosphere reserve. Kassel University Press. 7. **Peake, S., Innes, P., & Dyer, P.** (2009) Ecotourism and conservation: Factors influencing effective conservation messages. Journal of Sustainable Tourism, 17(1), 107–127. 8. **Pham, H. S. T., & Khanh, C. N. T.** (2021) Ecotourism intention: The roles of environmental concern, time perspective and destination image. Tourism Review, 76(5), 1141–1153. 9. **Powell, L. A., Edwards, R., et al.** (2018) Geography of ecotourism potential in the Great Plains: Incentives for conservation. Great Plains Research, 28(1), 15–24.

	10. **Yogi, H. N.** (2010) Ecotourism and sustainability: Opportunities and challenges in the case of Nepal.
Web Resources:	1. https://doi.org/10.1080/02508281.2017.1300211 2. https://doi.org/10.1080/03736245.2018.1522598 3. https://doi.org/10.5755/j01.em.18.3.4272 4. http://ndl.ethernet.edu.et/bitstream/123456789/26616/1/45.pdf.pdf 5. http://www.ecotourism.org/what-is-ecotourism 6. https://doi.org/10.1080/02508281.2021.1875170 7. https://hdl.handle.net/10474/1802 8. https://doi.org/10.3390/su14020800 9. https://ecotourism-world.com/ 10. https://www.orisysinfotech.com/best-practices-for- designing-an-ecotourism-website.php

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Title of the Course	Mushroom Biotechnology
Course Code	BOT-6402
Number of Credits	1 T + 1 P
Theory/Practical	Theory/Practical
Level	500
Effective from AY	2026-27
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	Yes

Pre-requisites for the Course:	Students should have undergone 400-level courses.	
Course Objectives:	• Impart knowledge on the diversity, biology, and domestication of mushrooms, including edible, medicinal, and toxic species. • Provide training in mushroom biotechnology, covering cultivation techniques, spawn development, substrates, and quality control. • Develop skills in harvesting, post-harvest processing, value addition, and marketing of mushrooms. • Enable students to evaluate the nutritional, medicinal, and biotechnological potential of mushrooms for food security, health, and entrepreneurship. • Prepare students for practical exposure, industry visits, and applied research in mushroom production and commercialization.	
Course Outcomes:	Students will be able to:	**Mapped to PSO**
	CO 1. Demonstrate knowledge of mushroom diversity, biology, edibility criteria, and domestication practices.	PSO 1, PSO 2

	CO 2. Apply concepts of infrastructure, substrates, spawn development, production techniques, and quality management in mushroom cultivation.		PSO 2, PSO 3	
	CO 3. Analyze post-harvest handling, grading, branding, value addition, and marketing strategies for edible and medicinal mushrooms.		PSO 3, PSO 4	
	CO 4. Evaluate the sustainability, nutritional value, and entrepreneurial potential of the mushroom industry at local, national, and global levels.		PSO 3, PSO 4	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	**Theory:** **1.1 Cultivation Technology:** Infrastructure, equipment, and substrates in mushroom cultivation. Diversity of mushrooms, edible, toxic, and medicinal mushrooms, criteria for edibility, and domestication of edible and medicinal mushrooms. Mushroom biotechnology of commercially cultivated species. **1.2 Substrates used in mushroom production:** Spawn development and quality parameters in commercially cultivated species. Scope for new species, scope in tropical countries. Production and quality management. **1.3 Harvesting, grading, branding, marketing:** Mushrooms-post-harvest processing, culinary preparations, and value addition. Storage, branding, and marketing, Future trends in the mushroom industry, National and global perspectives.	**15**	CO1, CO2, CO3, CO4,	K1, K2, K3, K4, K5, K6
Module 2:	**Practicals:** **2.1.** Identification of mushroom habitats. **2.2.** Identification of edible, medicinal, and toxic mushroom species. **2.3.** Preparation of pure cultures. **2.4.** Analysis of mushroom spore prints. **2.5.** Understanding the developmental biology of local wild mushrooms. **2.6.** Preparation, multiplication, and evaluation of mushroom spawn. **2.7.** Estimation of protein content in Oyster mushrooms. **2.8.** Extraction and qualitative analysis of phytochemicals from Oyster/Button mushrooms. **2.9.** Processing and preservation of mushrooms, economics of spawn, and mushroom production. **2.10.** Cultivation of Oyster mushrooms.	**30**	CO1, CO2, CO3, CO4	K1, K2, K3, K4, K5, K6

	2.11. Quality evaluation of Button or Oyster mushrooms. **2.12.** Visit to mushroom industry and submission of report			
Pedagogy:	Lectures/Tutorials/ICT-based learning/Assignments/Seminars/Videos.			
Text Books:	1. **Chang, S. T., & Hayes, W. A. (Eds.).** (2013) The biology and cultivation of edible mushrooms. Academic Press. 2. **Del Conte, A., & Laessoe, T.** (2008) The edible mushroom book: A gourmet's guide to foraging and cooking. Dorling Kindersley Ltd. 3. **Petre, M.** (2015) Mushroom biotechnology: Developments and applications. Elsevier.			
References/ Readings:	1. **Chang, S. T., & Miles, P. G.** (2004) Mushrooms: Cultivation, nutritional value, medicinal effect, and environmental impact (2nd ed.). CRC Press. 2. **Pandey, M., & Veena, S. S.** (2012) Characterization and conservation of edible and medicinal mushrooms of Western Ghats of India. Indian Journal of Tropical Biodiversity, 20(1), 37–44. 3. **Rathod, M. G., & Pathak, A. P., et al.** (2022) Biotechnology of mushroom (1st ed.). Bhumi Publishing. 4. **Rathod, M. G., & Pathak, A. P., et al. (Eds.).** (2022) Mushroom biotechnology for improved agriculture and human health. Wiley-Scrivener. 5. **Singh, M. P., Srivastava, A. K., Agrawal, A., & Sharma, B.** (2009) Mushroom biotechnology. In M. P. Singh, A. Agrawal, & B. Sharma (Eds.), Recent trends in biotechnology (Vol. 1, pp. 78–100). Nova Science Publishers. 6. **Stamets, P.** (2000) Growing gourmet and medicinal mushrooms (3rd ed.). Ten Speed Press.			
Web Resources:	1. https://hpuniv.ac.in/upload/uploadfiles/files/Mushroom%20cultivation.pdf 2. https://nhb.gov.in/pdf/Cultivation.pdf 3. https://tnagriculture.in/dashboard/CPG/12_Mushroom_Cultivation.pdf 4. https://extension.psu.edu/forage-and-food-crops/mushrooms/production-and-harvesting 5. https://www.mushroomoffice.com/mushroom-cultivation/ 6. https://gurunanakcollege.edu.in/files/science/mushroom-cultivation.pdf 7. https://pmc.ncbi.nlm.nih.gov/articles/PMC6132538/ 8. https://www.sciencedirect.com/book/9780128027943/mushroom-biotechnology			

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Title of the Course	Oenology (Wine Science and Technology)
Course Code	BOT-6403
Number of Credits	1T+1P
Theory/Practical	Theory and Practicals
Level	500
Effective from AY	2026-27
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	Yes

Pre-requisites for the Course:	Basic knowledge in microbiology.	
Course Objectives:	• Provide students with an understanding of oenology, wine production and sensory evaluation. • Train students in small-scale wine production and laboratory practices. • Familiarize students with wine chemistry, fermentation, and quality evaluation. • Provide knowledge of wine marketing, regulations, and tourism-related opportunities.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Explain the origin, history, types of wines, and terroir concepts.	PSO1, PSO2
	CO 2. Analyse grape and fruit processing, winemaking equipment, and fermentation principles.	PSO1, PSO3
	CO 3. Evaluate wine chemistry, microbial spoilage, quality control measures and conduct sensory evaluation.	PSO1, PSO2, PSO3

	CO 4. Apply knowledge of winemaking in small-scale production and tourism/industry contexts.		PSO3, PSO4	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	**Theory:** **1.1.** Overview of Oenology, ancient and modern methods of winemaking. **1.2.** Viticulture, grape species, wine types, styles, wine regions, Indian wine scene. **1.3.** Harvesting, processing of grapes/fruits, contamination, sanitation, sterilization, scales of winemaking. **1.4.** Chemistry & cell biology of fermentation, post-fermentation, wine analysis, chemical components, by-products, wine acids, aroma and phenolic compounds Terpenes, colour and flavour compounds. **1.5.** Sensory evaluation and quality control, microbial spoilage, wine defects and remedies. **1.6.** Wine bottling, corking, packaging, branding, marketing, alcohol marketing laws, revenue and excise policies. **1.7.** Role of wine in culture, industry, tourism, and employment prospects.	**15**	CO1, CO2, CO3, CO4	K2, K3, K4
Module 2:	**Practicals:** **2.1.** Identification of winemaking equipment. **2.2.** Culture and examination of yeast strains (wild type and *S. cerevisiae*). **2.3.** Microscale production of wine from fruits. **2.4.** Benchtop production and monitoring of wines from fruits, spices, and condiments. **2.5.** Organosensory evaluation of grape and other fruit wines. **2.6.** Analysis of alcohol content. **2.7.** Analytical testing (reducing sugars, pH, acidity, ammonia nitrogen, SO_2, turbidity, dissolved oxygen). **2.8.** Reporting on wine brands and marketing. **2.9.** Visit to wine distillery, evaluation of different types of wines, bottling, marketing.	**30**	CO2, CO3, CO4	K3, K4

Pedagogy:	Lectures/ICT tools/Assignments/Seminars/Lab practicals/ Industrial visits.
Texts:	1. **Amerine, M. A., Berg, H. W., Kunkee, R. E., Ough, C. S., Singleton, V. L., & Webb, A. D.** (1980) The technology of winemaking (4th ed.). A.V.I. Publishing Co. Inc. 2. **Fleet, G. H.** (1993) Wine microbiology and biotechnology. Harwood Academic Publishers. 3. **Jackson, R. S.** (2000) Wine science: Principles, practice, perception (2nd ed.). Academic Press. 4. **Jordão, A. M., & Cosme, F.** (2022) The application of wood species in enology: Chemical wood composition and effect on wine quality. Applied Sciences, 12(6), 3179. 5. **Ough, C. S.** (1991) Winemaking basics. Food Products Press. 6. **Ribéreau-Gayon, P., Glories, Y., Maugean, F., & Dubourdieu, D.** (2021) Handbook of enology: Volume 2 – The chemistry of wine stabilization and treatments. John Wiley & Sons. 7. **Storm, D. R.** (1997) Winery utilities: Planning, design and operation. Chapman & Hall. **8. Vine, R. P., Harkness, E. M., Browning, T., Wagner, C., &** 9. **Bordelon, B.** (1997) Winemaking: From grape growing to marketplace. Chapman & Hall. 10. **Yendell, K.** (2015) Winemaking: Fermenting, pressing, bottling, and aging- An introduction to oenology. CreateSpace Independent Publishing Platform.
References/ Readings:	1. **Lárez Velásquez, C.** (2023) Chitosan and its applications in oenology. OENO One, 57(1), 103–122. 2. **Mouret, J.-R., Aguera, E., Perez, M., Farines, V., & Sablayrolles, J.-M.** (2021) Study of oenological fermentation: Which strategy and which tools? Fermentation, 7(3), 155. 3. **Pretorius, I. S.** (2019) Yeast and its importance to wine aroma – A review. South African Journal of Enology and Viticulture, 21(1), 22–46. 4. **Belda, I., Zarraonaindia, I., Perisin, M., Palacios, A., & Acedo, A.** (2022) Microbial interactions in winemaking: Ecological aspects and effect on wine quality. Trends in Food Science & Technology, 127, 99–113. 5. **Rossouw, D., & Bauer, F. F.** (2016) Wine science in the omics era: The impact of systems biology on the future of wine research. South African Journal of Enology and Viticulture, 37(1), 11–27.
Web Resources:	1. http://www.wineserver.ucdavis.edu 2. http://www.ajevonline.org 3. http://www.infowine.com

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Title of the Course	Agro-Technology
Course Code	BOT-6404
Number of Credits	1T+1P
Theory/Practical	Theory and Practical
Level	500
Effective from AY	2026-27
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	Yes

Pre-requisites for the Course:	Nil	
Course Objectives:	• Introduce students to principles and practices of modern and traditional Agro-technologies. • Familiarize with sustainable and innovative methods like precision farming, hydroponics, organic farming, and integrated pest management. • Highlight the importance of Agro-technological approaches in food security and sustainable agriculture.	
Course Outcomes:	Students will be able to:	**Mapped to PSO**
	CO 1. Understand the role of Agro-technology in modern agriculture.	PSO1, PSO2
	CO 2. Demonstrate nursery raising, composting, and protected cultivation practices.	PSO3, PSO4
	CO 3. Apply soil health, irrigation, nutrient and integrated pest management technologies.	PSO2, PSO3
	CO 4. Analyse Next-Gen Agro-tools (GIS, remote sensing, precision farming).	PSO1, PSO4

Content:		No of hours	Mapped to CO	Cognitive Level
Module 1:	**Theory:** **1.1.** Scope of Agro-Technology and its importance in modern agriculture; soil health management and biofertilizers; protected cultivation: greenhouse, shade-net, hydroponics; Irrigation technology: drip and sprinkler systems; Smart agriculture sensors, soil moisture sensors, IoT devices, automated irrigation controllers. **1.1.** Crop improvement through biotechnology and molecular tools; Agro-biotechnology and Nanotechnology Applications, Use of nanofertilizers, nanopesticides, biosensors, and molecular tools for crop health monitoring and precision delivery of nutrients; Integrated pest and disease management (IPDM). **1.2.** Post-harvest technologies and value addition in agriculture; Agro-waste valorization, converting crop residues into biochar, compost, bioplastics; Climate-Smart Agriculture and Carbon Farming, Low-carbon agriculture practices, carbon sequestration through agroforestry. **1.3.** Role of ICT (GIS, remote sensing, drones) in precision agriculture; sustainability and climate-resilient agro-technologies; Agro-entrepreneurship: agritech startups; Regulatory and policy aspects, Indian government schemes (PM-Kisan, e-NAM, Pradhan Mantri Krishi Sinchayee Yojana), Swayampurna Goa, Organic Farming Scheme, Krishi Card, Goa AgriStack/GAFR (Goa Farmer Registration Portal)	**15**	CO1, CO2, CO3, CO4	K2, K3, K4
Module 2:	**Practicals:** **2.1.** Study of soil health parameters (pH, EC, organic carbon, NPK). **2.2.** Isolation of beneficial soil microbes (*Rhizobium*, *Bacillus*, *Pseudomonas*). **2.3.** Preparation and application of biofertilizers (Rhizobia, Cynobacteria, PGPB). **2.4.** Preparation and application of biopesticides (Microbial Biopesticide-Bacterial/Fungal, Plant derived Biopesticides- Neem, *Lantana camara*). **2.5.** Nursery raising and vegetative propagation methods. **2.6.** Vermicomposting and organic manure preparation.	**30**	CO2, CO3, CO4	K2, K3, K4

	2.7. Small-scale hydroponic setup and monitoring plant growth in nutrient solution. **2.8.** Preparation of biocontrol formulation (*Trichoderma*/*Bacillus*). **2.9.** Demonstration of post-harvest handling and storage methods (grading, packaging). **2.10.** Introduction to precision agriculture tools (GPS-based soil mapping, mobile apps for crop monitoring). **2.11.** Field visit to Krishi Vigyan Kendra /Agricultural Research Institute/Agritech start up.			
Pedagogy:	Classroom lectures, ICT-based learning, seminars, assignments, laboratory practicals, field visits			
Texts:	1. **Balasubramanian, P., Palaniappan, S. P., & Muthukrishnan, P.** (2017) Principles and Practices of Agronomy. Jodhpur: Scientific Publishers. 2. **Bhattacharyya, P.** (2019) Soil Fertility and Nutrient Management. New Delhi: Kalyani Publishers. 3. **Channabasavanna, A. S.** (2018) Agro-Technology: A Sustainable Approach. Houston: Studium Press. 4. **Chopra, V. L., & Panwar, R.** (2020) Agricultural Biotechnology. New Delhi: Oxford & IBH Publishing. 5. **Gupta, U. S.** (2019) Crop Production and Management: Principles and Practices. New Delhi: New India Publishing Agency. 6. **Lal, R.** (2021) Soil Science and Sustainable Agriculture. Boca Raton: CRC Press. 7. **Lichtfouse, E.** (2018) Sustainable Agriculture Reviews (Vols. 1–30). Cham: Springer International. 8. **Panda, S. C.** (2019) Crop Production and Sustainable Agriculture. Jodhpur: Scientific Publishers. 9. **Reddy, S. R.** (2016) Principles of Agronomy (6th ed.). Kalyani Publishers. 10. **Singh, R. P., & Singh, S.** (2020) Modern Agro-Technologies. New Delhi: New India Publishing Agency. 11. **Tisdale, S. L., Havlin, J. L., Beaton, J. D., & Nelson, W. L.** (2019) Soil Fertility and Fertilizers (9th ed.). New Delhi: Pearson India. 12. **Verma, L. R., & Sarma, H.** (2019) Farming System and Sustainable Agriculture. New Delhi: CBS Publishers & Distributors.			
References/ Readings:	1. **Choudhary, M., Kumar, A., & Singh, R.** (2021) Smart farming technologies for sustainable agriculture: A review. Journal of Cleaner Production, 285, 124941.			

	2. **Kaur, S., Manchanda, P., & Kaur, G.** (2022) Recent advances in nanotechnology applications in agriculture for sustainable crop production. Frontiers in Plant Science, 13, 946894. 3. **Mahlein, A. K.** (2016) Plant disease detection by imaging sensors – Parallels and specific demands for precision agriculture. Plant Disease, 100(2), 241–251. 4. **Pandey, S., Singh, A., & Tiwari, R.** (2021) Hydroponics: A modern technology for smart agriculture. Sustainable Agriculture Reviews, 50, 133–151. 5. **Ray, D. K., Mueller, N. D., West, P. C., & Foley, J. A.** (2013) Yield trends are insufficient to double global crop production by 2050. PLoS ONE, 8(6), e66428. 6. **Reddy, A. R., & Reddy, M. K.** (2019) Recent trends in climate-smart agriculture. Current Opinion in Environmental Sustainability, 40, 56–61. 7. **Srivastava, P., Singh, R., Tripathi, S., & Tewari, R.** (2021) Precision agriculture technologies for sustainable farming: A review. Agronomy, 11(9), 1730. 8. **Verma, S., & Singh, S. P.** (2020) Controlled environment agriculture for food security and climate change resilience. Environmental Sustainability, 3, 203–210.
Web Resources:	1. https://elearning.fao.org 2. https://www.cgiar.org 3. https://agris.fao.org 4. https://www.frontiersin.org/journals/plant-science 5. https://link.springer.com/journal/13593

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Title of the Course	Eco-Crafts and Sustainable Lifestyle Products
Course Code	BOT-6405
Number of Credits	1 T + 1 P
Theory/Practical	Theory & Practicals
Level	500
Effective from AY	2026-27
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	Yes

Pre-requisites for the Course:	Nil	
Course Objectives:	• Understand the concepts, resources, and scientific basis of eco-crafts and sustainable plant-based innovations. • Apply knowledge of plant-derived raw materials, natural dyes, herbal extracts, and eco-friendly technologies in developing lifestyle and cosmetic products. • Demonstrate practical skills in fabricating eco-crafts, herbal cosmetics, and sustainable alternatives through laboratory and hands-on sessions. • Evaluate the ecological, economic, and entrepreneurial potential of eco-crafts and herbal products in the context of circular economy and sustainable development. • Design and innovate eco-friendly lifestyle/cosmetic products with emphasis on bio-entrepreneurship, green chemistry, and indigenous knowledge systems.	
Course Outcomes:	Students will be able to:	**Mapped to PSO**

	CO 1. Explain the foundations of eco-crafts, sustainable product design, and global sustainability goals.		PSO 1, PSO 4	
	CO 2. Analyze plant-based raw materials (fibers, dyes, polymers, essential oils) and their applications in eco-crafts, herbal cosmetics, and sustainable lifestyle products.		PSO 1, PSO 2	
	CO 3. Demonstrate practical skills in preparing eco-crafts, herbal cosmetics, and sustainable household products using green technologies.		PSO 3, PSO 4	
	CO 4. Evaluate eco-friendly alternatives, formulations, and green chemistry-based methods for their sustainability and bioprospecting potential.		PSO 2, PSO 4	
	CO 5. Design and innovate new sustainable lifestyle/herbal cosmetic products, integrating scientific knowledge with entrepreneurial perspectives.		PSO 3, PSO 4	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	**Theory:** **Eco-Crafts: Concepts, Resources, and Innovations:** **1.1. Foundations of Eco-Crafts and Sustainability** Concept, scope, and evolution of eco-crafts; Role of plant-based resources in promoting sustainable lifestyles; Life Cycle Assessment (LCA) of eco-friendly products; Global sustainability goals (UN-SDGs) and their link to eco-crafts. **1.2. Advanced Plant-Based Raw Materials for Eco-Crafts** Fibres: Cotton, Coir, Agave (Sisal), Flax, Kenaf, Jute, Hemp, Abaca, banana, *Helicteres isora* (Kevan) Pineapple, *Careya arborea* (Kumbyo) - physical and mechanical properties; Natural dyes: phytochemical basis of colorants (anthocyanins, carotenoids, flavonoids, tannins); Plant-based polymers, resins, gums, adhesives, and essential oils; Valorization of agro-waste, industrial by-products, and recycled plant materials. **1.3. Crafting, Processing, and Green Technologies** Traditional eco-craft practices and their scientific basis; Techniques of handmade paper, biodegradable packaging, and leaf/bamboo-based products; Methods of dye extraction and fixation; role of mordants and eco-friendly alternatives; Green chemistry approaches	**15**	**CO 1, CO 2, CO 4**	**K 2, K 4, K 5**

	in product development (biodegradable solvents, low-carbon processes); Integration of indigenous knowledge systems with modern innovations. **1.4. Eco-Friendly Lifestyle Products and Innovations** Herbal personal care: formulation of soaps, shampoos, cosmetics; Biodegradable household products: natural detergents, bio-cleaners; Nutraceuticals and functional foods derived from plants; Case studies of market-ready sustainable innovations and start-ups. **1.5. Entrepreneurship, Policies, and Future Trends** Eco-crafts in circular economy and livelihood security; Business models, value addition, and branding of eco-craft products; Policy frameworks: AYUSH, MSME, biodiversity and IPR considerations; Emerging trends: biomaterials, nanotechnology in eco-products, sustainable packaging, and climate-smart product design.			
Module 2:	**Practicals:** **Eco-Crafts from Natural Fibers and Plant-Based Materials** **2.1.** Preparation of eco-friendly handmade paper using floral waste, husks, or leaves. **2.2.** Extraction of natural dyes (Turmeric, Indigo, Annatto, Beetroot, Onion peels) and dyeing of cloth/fiber. **2.3.** Fabrication of jute or coir-based eco-crafts (coasters, mats, simple utility items). **2.4.** Leaf/flower impression printing on handmade paper or fabric. **2.5.** Preparation of eco-friendly seed balls and biodegradable pots. **2.6.** Preparation of plates from leaves of Jackfruit/Banyan/Chara/Palas.	**10**	**CO 2, CO 3**	**K3, K4**
Module 3:	**Practicals:** **Herbal Products and Cosmetics** **3.1.** Preparation of herbal soaps using plant extracts (*Azadirachta indica* (neem)/*Ocimum tenuiflorum* (Tulsi)/*Aloe vera*). **3.2.** Formulation of herbal shampoo and conditioner [*Acacia concinna* (shikakai)/*Hibiscus rosa-sinensis*/*Phyllanthus emblica* (amla)/ *Sapindus mukorossi* (reetha)].	**10**	**CO 2, CO 3, CO 5**	**K3, K4, K6**

	3.3. Preparation of herbal face pack and scrubs using plant powders [*Santalum album* (sandalwood)/*Curcuma longa* (turmeric)/ *Azadirachta indica* (neem)/Bentonite Clay (multani mitti)]. **3.4.** Formulation of herbal lip balm or lip gloss using natural waxes, oils, and pigments. **3.5.** Preparation of natural creams/lotions or gels using *Aloe vera*/essential oils and other plant materials.			
Module 4:	**Practicals:** **Sustainable Lifestyle and Innovative Products** **4.1.** Preparation of herbal hand sanitizers/cleansers using plant-based alcohol or extracts. **4.2.** Fabrication of eco-friendly candles or essential oil diffusers using natural wax and plant oils. **4.3.** Preparation of bio-enzyme cleaning agents using citrus peels, jaggery, yeast and water. **4.4.** Development of eco-friendly jewelry or decorative items from seeds, clay, shells. **4.5.** Preparation of traditional products from Coconut palm. **4.6.** Project-based mini-innovation: Designing a sustainable lifestyle or cosmetic product such as biodegradable packaging for cosmetics, herbal deodorant/plant-based cutlery/probiotics/green-tea/yogurt/ice cream.	**10**	**CO 3, CO 4, CO 5**	**K3, K5, K6**
Pedagogy:	Lectures/Interactive Tutorials/Concept-based Assignments/Field-visits/ICT-based learning/Hands-on practicals/Demonstrations/ Peer Discussions/Seminars and mini-projects.			
Texts:	1. **Gittemarie, Johansen**. (2022) Sustainable Badass (A Zero-Waste Lifestyle Guide), Mango Publishing Group, USA. 2. **Harper, Calderwood.** (2025) Sustainable Solutions for a Greener Home Eco-Friendly DIY Projects for a Healthy Planet, independently published. 3. **Hosey, L.** (2012) The shape of green: aesthetics, ecology, and design. Island Press. 4. **Jilakara, V. S., Reddy, G. N., Jadhav, R. S., & Maru, A. D.** (2020) Herbal Cosmetics. JEC Publication. 5. **Maria, Correas-Amador.** (2022) The Stuff of Life - Ancient Inspiration for Sustainable Living, Publish drive Incorporated.			

	6. **Rakesh, R., Jadhav, Apurba. Saikia., Chandan, Das.** (2022) Eco-friendly Products for Sustainable Environment Development, Amazon Digital Services LLC-Kdp, India 7. **Salah, El-Haggar, Aliaa, Samaha.** (2019) Roadmap for Global Sustainability – Rise of the Green Communities, Springer Nature, Switzerland.
References/ Readings:	1. **Charter, M., & Tischner, U. (Eds.). (2017)** Sustainable solutions: developing products and services for the future. Routledge. 2. **Curran, M. A. (Ed.). (2012)** Life cycle assessment handbook: a guide for environmentally sustainable products. John Wiley & Sons. 3. **Duerr, S.** (2020) Natural Palettes: Inspirational Plant-Based Color Systems. Chronicle Books.Philipp Frühwirth (2023) Eco-Crafts: Making Beautiful Things with Natural Materials, independently published. 4. **Gwilt, A. (2020)** A practical guide to sustainable fashion. Bloomsbury Publishing. 5. **Hosey, L. (2012)** The shape of green: aesthetics, ecology, and design. Island Press. 6. **Marchand, A., & Walker, S.** (2008) Product development and responsible consumption: designing alternatives for sustainable lifestyles. Journal of Cleaner Production, 16(11), 1163-1169. 7. **Thakker, A. M., & Sun, D.** (2021) Sustainable plant-based bioactive materials for functional printed textiles. The Journal of the Textile Institute, 112(8), 1324-1358. 8. **Sears, C. E. (2024)** Botanical Bar Craft: A Guide to the Art of Apothecary Cocktails and Herbal Tonic Elixirs. Chelsea Green Publishing. 9. **Wakkary, R., Desjardins, A., Hauser, S., & Maestri, L.** (2013) A sustainable design fiction: Green practices. ACM Transactions on Computer-Human Interaction (TOCHI), *20*(4), 1-34.
Web Resources:	1. Google.co.in/Eco-friendly Products for Sustainable 2. Khushabu Gupta (2025) Sustainable Living made Simple, E-book. https://play.google.com/books/reader?id=LHGCEQAAQBAJ&pg=GBS.PA6&hl=en

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SEMESTER IV

Generic Elective (GE) Courses

Title of the Course	Seed Science and Technology
Course Code	BOT-6201
Number of Credits	4
Theory/Practical	Theory
Level	500
Effective from AY	2026-27
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	Yes

Pre-requisites for the Course:	Students should have undergone 400 level course.	
Course Objectives:	• Facilitate a deeper understanding of various aspects of seed science and technology. • Impart knowledge of seed processing and seed quality enhancement techniques. • Provide conceptual understanding of seed marketing and its structure. • Perceive awareness of the seed laws and seed policies.	
Course Outcomes:	Students will be able to:	**Mapped to PSO**
	CO 1. Understand the basic concepts of seed and scientific principles of seed production.	PSO 1

	CO 2. Interpret equipments for seed conditioning, cleaning, grading, their working principle and function in seed processing.		PSO 1, PSO 3	
	CO 3. Explain the seed quality enhancement techniques, seed conservation, principles of seed storage.		PSO 1, PSO 3	
	CO 4. Analyse the phases of seed germination, dormancy types and seed viability tests of agricultural and horticultural crops.		PSO 1, PSO 3	
	CO 5. Compare the seed marketing structure, distribution and demand of seed trade.		PSO 1, PSO 2	
	CO 6. Evaluate methods of field inspection, including field count, post-harvest inspection, seed certification and enforcement of seed law and regulation.		PSO 2, PSO 4	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	**Concepts and Principles of Seed science and Technology** **1.1. Concept of seed technology:** Seed quality, definition, importance, and goals of seed technology; types of seed programmes; Steps involved in developing a seed programme. Characters of good quality seeds, Seed development and maturation. **1.2. General Principals of seed production and Seed Processing:** Genetic and agronomic principles; Maintenance of nucleus seed; production of Breeder, Foundation, and Certified seed; principles of seed processing; methods of seed drying. **1.3. Seed cleaning equipment and their functions:** Functions of Scalper, Debearder, Scarifier, Huller, Seed Cleaner, and Grader. Screen cleaners, specific gravity separators, indented cylinders, velvet-spiral-disc separators, colour sorters, and delinting machines.	**15**	**CO1, CO2**	**K1, K2, K3**
Module 2:	**Seed quality enhancement techniques of crop plants** **2.1. Seed treatment:** Types of seed treatment, seed treating formulations and equipment, seed disinfestations, identification of treated seeds; packaging materials: principles, practices, and materials; bagging and labelling. Seed quality enhancement techniques, seed priming, seed coating, and seed pelleting. **2.2. Seed storage:** Principles of seed storage; seed drying, the importance of seed drying; factors affecting seed longevity during storage, changes during storage, concepts and	**15**	**CO3, CO4**	**K1, K2, K3, K4**

	significance of moisture equilibrium, methods of maintaining safe seed moisture content. Methods to minimize the loss of seed vigour and viability; factors influencing storage losses. Measures for pest and disease control during storage and godown sanitation; Storage structures. Storage problems of recalcitrant seeds and their conservation. Genetic changes during seed storage. **2.3. Seed germination methods:** Germination-phases of seed germination; Dormancy-types of seed dormancy; T.T.C. test; Embryo excision method.			
Module 3:	**Seed Marketing and management** **3.1. Seed Distribution:** Seed distribution through government, public sector agencies, co-operatives and private sector; Sources of seed availability to farmers; Seed schemes for farmer empowerment; factors affecting seed distribution and demand; Seed promotional activities. **3.2. Seed Marketing:** Seed marketing structure and organizational chart; International Seed Trade Federation (ISF) and Indian seed associations; Market survey and seed pricing policies; marketing channels; planning and sales; Seed marketing intelligence and product mix; Seed import and export. **3.3. Seed Demand in Seed sector:** Strengths and weaknesses of seed sector; Importance and scope of seed industry in India; Role of seed replacement rate (SRR), seed multiplication ratio (SMR); Cost of seed production and returns; determining seed needs; economic feasibility of seed industry.	**15**	**CO4, CO5**	**K1, K3, K4, K5**
Module 4:	**Field management and Seed Laws and Regulations** **4.1. Field Inspection:** Method of inspection; field counts; field and seed standards; post-harvest inspection; specifications for tags and labels. Duties and powers of Seed Inspector. **4.2. Seed Certification:** Objectives of seed certification; legal status and phases of seed certification; procedure for seed certification; formulation, revision, and publication of seed certification standards. **4.3. Seed Legislation and Seed Law Enforcement:** Seed Act and rules; Seed Legislation in India; Regulatory legislations; Seed Law Enforcement; Seed Control Order, 1983; The Plant varieties Act, National Seed Policy 2002; Seed Bill 2004.	**15**	**CO5, CO6**	**K2, K3, K4, K5, K6**

Pedagogy:	Lectures/Assignments/Seminars/Group Discussions/Mini Projects
Text Books:	1. **Amarjit, Basra.** (2024) Handbook of Seed Science and Technology. CRC Press, Taylor & Francis Group, Boca Raton, Florida. 2. **Gour, Lokesh., Patel, D., & Lal, L.** (2020) Textbook of Seed Science and Technology. Agrotech Publishing Academy, Udaipur, India. 3. **Sai, Prasad, S.V., Verma, S., & Jat, D.** (2018) Seed Science and Technology. New Vishal Publications, New Delhi, India.
References/ Readings:	1. **Acharya, S.S.** (2004) Agricultural marketing in India. Oxford and IBH., New Delhi. 2. **Agarwal, R. L.** (2018) Seed Technology. India: Oxford and I.B.H. Publishing Company Pvt. Limited. 3. **Agrawal, P. K.** (1993) Handbook of Seed Testing. Ministry of Agriculture, G.O.I., New Delhi. 4. **Agrawal, P. K., & Dadlani, M.** (1992) Techniques in Seed Science and Technology. 2nd Ed. South Asian Publications. 5. **Copland, L.O. & McDonald, M. B.** (1996) Principles of Seed Science and Technology. Kluwer. 6. **ISTA., (**2006) Seed Testing Manual. ISTA, Switzerland. 7. **Joshi, A.K., & Singh, B. D.** (2004) Seed Science and Technology. Kalyani Publishers, New Delhi. 8. **Martin, C., & Barkley, D.** (1961) Seed Identification Manual. Oxford & I.B.H. Berkeley, University of California Press. 9. **McDonald, M. F., & Copeland, L. O.** (2012) Principles of Seed Science and Technology. United States: Springer US. 10. **Payasi, S. K. & Katkani, D.** (2021) Technology. Brillion Publishers, New Delhi. 11. **Singh, P.** (2013) Principles of Seed Technology. Kalyani Publishers, New Delhi. 12. **Subir, Sen. & Nabinananda, Ghosh.** (2014) Seed Science and Technology. Kalyani Publishers, New Delhi. 13. **Tunwar, N. S. & Singh S. V.** (1988) Indian Minimum Seed Certification Standards. Central Seed Certification Board, Ministry of Agriculture, New Delhi.
Web Resources:	1. https://seednet.gov.in 2. https://agritech.tnau.ac.in 3. https://prsindia.org/

	4. https://asoca.assam.gov.in/ 5. https://www.iari.res.in 6. https://www.seedtest.org/ 7. https://www.uasbangalore.edu.in/

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Title of the Course	Post-harvest Technology for Fruit Crops
Course Code	BOT-6202
Number of Credits	2
Theory/Practical	Theory
Level	500
Effective from AY	2026-27
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	Yes

Pre-requisites for the Course:	Students should have undergone 400 level courses.	
Course Objectives:	• Provide in-depth knowledge in the field of post-harvest technology and processing of various fruit crops. • Understand the maturity indices, postharvest physiology, various storage and packaging methods. • Evaluate the methods of processing of various fruits, value added products and postharvest diseases.	
Course Outcomes:	Students will be able to:	**Mapped to PSO**
	CO 1. Understand the concepts of post-harvest technology and processing of various fruit crops.	PSO 1
	CO 2. Interpret maturity indices of various tropical and temperate fruits.	PSO 1, PSO 2
	CO 3. Apply various physiological process to variety of fruit crops.	PSO 1, PSO 2
	CO 4. Analyze and compare the nutritional value of wide range of fruit crops and quality of fruits.	PSO 1, PSO 3
	CO 5. Evaluate the methods for storage of fruits and transportation, and methods for preservation of fruits and processed fruit products.	PSO 3, PSO 4

Content:		No of hours	Mapped to CO	Cognitive Level
Module 1:	**Post-harvest principles, maturity indices and post-harvest physiology** **1.1. Principles of Post-harvest technology and Maturity indices of Fruits:** Concepts, tropical fruits, major fruit crops of Goa, post-harvest and processing status of fruits (Kokum, Jamun, Amla and other wild edible fruits); maturity indices, harvesting practices for specific market requirements, influence of pre-harvest practices. **1.2. Postharvest Physiology of Fruit Crops:** Enzymatic and textural changes, respiration, transpiration, temperature, physiology and biochemistry of fruit ripening, ethylene evolution and ethylene management, factors leading to post-harvest loss, pre-cooling.	**15**	CO1, CO2	K1, K2, K3,K4,K5
Module 2:	**Post-harvest treatments, storage, packaging, fruit preservation and safety** **2.1. Treatments prior to shipment and Storage of fruits:** Chlorination, waxing, chemicals, bio-control agents and natural plant products. Methods of storage - ventilated, refrigerated, modified atmospheric storage (MAS), controlled atmospheric storage (CAS), physical injuries and disorders. **2.2. Packing methods and transport:** Principles and methods of preservation, food processing, canning, fruit juices, squashes, beverages, pickles, jams, jellies, candies. **2.3. Methods of fruit preservation, products and food safety:** Dried and dehydrated products, nutritionally enriched products, fermented fruit beverages, packaging technology, processing, fruit waste management, food safety standards.	**15**	CO3, CO4, CO5,	K2, K3, K4, K5
Pedagogy:	Lectures/Assignments/Seminars/ICT tools/Group Discussions/Mini Projects			
Text Books:	1. **Sudheer K. P and Indira V.** (2007) Post Harvest Technology of Horticultural Crops. New India Publishing Agency, New Delhi. 2. **Wim Jongen** (Ed.) (2002) Fruit and vegetable processing. Improving quality. Woodhead Publishing Ltd., Cambridge, UK and CRC press, New York, USA.			
References/ Readings:	1. **BhimPratap, Singh., Shekhar, Agnihotri., Garima, Singh., Vijai Kumar, Gupta.** (2023) Postharvest Management of Fresh Produce: Recent Advances, Academic Press. 2. **Bhutani, R. C. (**2003) Fruit and Vegetable Preservation. Biotech Books Publishing House, Delhi. 3. **Chadha, K. L & Pareek O. P.** (Eds.) (1996) Advances in Horticulture. Vol. IV. Malhotra Publishing House. Delhi.			

	4. **Debbie, Rees., Graham, Farrell. & John, Orchard.** (Eds.) (2012) Crop Post-Harvest: Science and Technology. Wiley-Blackwell, UK. **5.** Graham, Farrell., John, Orchard., & Debbie, Rees. (Eds) **(2012) Crop Post-Harvest: Science and Technology, Volume 3: Perishables, Wiley-blackwell, UK.** 6. **Haid, N. F., & Salunkhe, S. K.** (1997) Post Harvest Physiology and Handling of Fruits and Vegetables. Grenada Publishers, USA. **7. Mandal, R. C.** (2007) Cashew Production and Processing Technology. AGROBIOS (India), Jodhpur. 8. **Mitra, S. K.** (1997) Post Harvest Physiology and Storage of Tropical and Sub-tropical Fruits. CABI, UK. 9. **Patil, R. T., Desh, Beer. Singh., & Gupta, R. K.** (2009) Post Harvest Management of Horticultural Produce Recent Trends. Daya Publishing House, Delhi. 10. **Ranganna, S.** (1997) Hand Book of Analysis and Quality Control for Fruit and Vegetable Products. Tata McGraw-Hill, Delhi. 11. **Srivastava**, **R. P., & Sanjeev Kumar. (**2019) Fruits and vegetable preservation principles and practices revised and enlarged, 3rd edition, **CBS Publishers & Distributors, New Delhi.** 12. **Willis, McGlassen, W. B., Graham, D., & Joyce, D.** (1998) Post Harvest. An Introduction to the Physiology and Handling of Fruits, Vegetables and Ornamentals. CABI, UK.
Web Resources:	1. https://agritech.tnau.ac.in 2. https://fmipa.umri.ac.id/wp-content/uploads/2016/03/Amalendu_Chakraverty_Arun_S._Mujumdar_HosahalliBookFi.org_.pdf 3. chromeextension://efaidnbmnnnibpcajpcglclefindmkaj/https://nhb.gov.in/documents/storage-manual.pdf 4. chromeextension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.destechpub.com/wp-content/uploads/2015/01/Post-harvest-Technologies-of-Fruits-Vegetables-preview.pdf?srsltid=AfmBOoqrq0QBibHsEGLBR4TKqfyYH6Sl1HJfDtx2XAozyztLGgD09AOC extension://efaidnbmnnnibpcajpcglclefindmkaj/https://cpur.in/library/Books/81.%20Post-Harvest%20Management%20And%20Value%20Addition%20Of%20Fruits%20And%20Vegetables.pdf 5. chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://download.e-bookshelf.de/download/0000/5875/11/L-G-0000587511-0002361679.pdf 6. https://www.scribd.com/document/731787062/Post-Harvest-Management-S-K-sharMA-BOOK

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Title of the Course	Ethnobotany
Course Code	BOT-6203
Number of Credits	2
Theory/Practical	Theory
Level	500
Effective from AY	2026-27
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	Yes

Pre-requisites for the Course:	Students should have undergone 400-level courses.	
Course Objectives:	• Impart knowledge in ethnobotany, methods of collecting ethnobotanical data, and the commercial use of traditional knowledge. • Provide an understanding of the history, scope, and interdisciplinary foundations of ethnobotany. • Train students in identifying and utilizing diverse sources of ethnobotanical data and applying field research methods ethically. • Develop the ability to critically analyze traditional plant knowledge, folk taxonomies, and community practices in relation to livelihoods, culture, and conservation. • Foster skills in evaluating the bioprospecting potential of plants, managing intellectual property rights, and integrating traditional knowledge with modern science for sustainable innovations.	
Course Outcomes:	Students will be able to:	**Mapped to PSO**
	CO 1. Explain the history, scope, interdisciplinary approaches, and data sources in ethnobotany.	PSO 1, PSO 2

	CO 2. Apply field research methods such as PRA, interviews, questionnaires, and ethical guidelines to collect and interpret ethnobotanical knowledge.		PSO 2, PSO 3	
	CO 3. Critically analyze folk taxonomies, NTFPs, and ethno-mycological knowledge in relation to community livelihoods, conservation, and cultural practices.		PSO 2, PSO 4	
	CO 4. Evaluate bioprospecting opportunities, intellectual property rights, and benefit-sharing models, integrating traditional knowledge with modern science for sustainable innovations		PSO 4	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	**1.1.** Introduction: Brief history of ethnobotanical studies in the world and India; Scope of ethnobotany. Subdisciplines of ethnobotany. Interdisciplinary approaches. Knowledge of sociological and anthropological terms. **1.2.** Distribution of tribes in India. Knowledge of tribes of Konkan, Goa, and Kanara; Ethnobotanical work on these tribes. **1.3.** Sources of ethnobotanical data: Primary - archaeological sources and inventories, Secondary - travelogues, folklore and literary sources, herbaria, medicinal texts, and official records. Methods in ethnobotanical research. Research design and cautions in data collections, Practical and field skills; Prior informed consent, Participatory Rural Appraisal (PRA) techniques, interviews and questionnaire methods, choice of resource persons.	**15**	CO1	K1, K2, K3, K4
Module 2:	**2.1.** Ethnobotanical knowledge and communities: Ethnobotanical classification; Folk taxonomy of plants. Non-Timber Forest Produce (NTFP) and livelihood. Sustainable harvest and value addition. Ethno-mycology. Conservation and community development. **2.2.** Bioprospecting and commercial use of traditional knowledge; Medical ethnobotany, ethno-pharmacology and the search of plant-based drugs. Developing research partnerships: Ethics and research guidelines in ethnobotany, equitable research relationships. **2.3.** Traditional knowledge (TK) and Traditional Knowledge Digital Library (TKDL) in relation to Intellectual Property Rights and Biopiracy. Equitable Benefit Sharing models of the world. **2.4.** Ethnobotany and People's Biodiversity Register (PBR). Practical applications of	**15**	CO2	K2, K3, K4, K5, K6

	ethnobotanical data; Ethno-medicine and primary health care; Ethnobotany and ethno-pharmacology as a tool to protect the interests of ethnic groups and rural development.			
Pedagogy:	Lectures/Tutorials/ICT tools/Assignments/Seminars/ Field visit			
Text Books:	1. **Balick, M. J., & Cox, P. A.** (2021) *Plants: people, and culture: The science of ethnobotany* (2nd ed.). CRC Press. 2. **Bussmann, R. W.** (Ed.). (2022) *Ethnobotany of mountain regions.* Springer. 3. **Ghate, V., Sane, H., & Ranade, S. S.** (Eds.). (2004) Focus on Sacred Groves and Ethnobotany: Proceedings of the National Seminar on Ethnobotany & Sacred Groves:" Role in Conservation Strategy for India"... Along with Original Papers by Dr. VD Vartak. Prism Publications. 4. **Jain, S. K.** (2021) *Manual of ethnobotany*. (2nd rev. ed.). Scientific Publishers. 5. **Martinez, J. L., Maroyi, A., & Wagner, M. L.** (Eds.). (2023) *Ethnobotany: From the traditional to ethnopharmacology.* Research Trends.			
References/ Readings:	1. **Heinrich, M., & Jäger, M**. (2015) *Ethnopharmacology*. Wiley-Blackwell. 2. **Jain, S. K.** (1991) Contributions to ethnobotany of India. 3. **Jain, S. K.** (2010) Manual of ethnobotany. Scientific publishers. 4. **Pullaiah, T.** (2002) *Handbook of ethnobotany*. Regency Publications. 5. **Saklani, A., & Jain, S. K.** (1989) Ethnobotanical observations on plants used in northeastern India. International Journal of Crude Drug Research, 27(2), 65-73. 6. **Schultes, R. E., & von Reis, S.** (1995) *Ethnobotany: Evolution of a discipline. C*hapman and Hall.			
Web Resources:	1. https://www.fao.org/4/i0841e/i0841e00.htm 2. https://link.springer.com/search?query=ethnobotany 3. https://nbaindia.org			

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Title of the Course	Sustainable Agriculture
Course Code	BOT-6204
Number of Credits	2
Theory/Practical	Theory
Level	500
Effective from AY	2026-27
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	Yes

Pre-requisites for the Course:	Basic knowledge of plant biology, ecology.	
Course Objectives:	• Introduce students to the concepts, scope, and principles of sustainable agriculture. • Provide knowledge of soil, water, crop, and pest management for long-term agricultural sustainability. • Analyze climate-smart strategies, innovative farming practices, and policies for resilient agricultural systems.	
Course Outcomes:	Students will be able to:	**Mapped to PSO**
	CO 1. Understand the principles, scope, and challenges of sustainable agriculture.	PSO1, PSO2
	CO 2. Apply eco-friendly approaches in soil, crop, and water management.	PSO2, PSO3
	CO 3. Analyze sustainable farming systems and their impacts on productivity and environment.	PSO2, PSO3, PSO4
	CO 4. Evaluate and propose sustainable agriculture strategies in the context of climate change and resource conservation, using traditional knowledge and modern technologies.	PSO2, PSO4

Content:		No of hours	Mapped to CO	Cognitive Level
Module 1:	**Sustainable Agriculture and Farming Systems** **1.1.** Concept, definition, and scope of sustainable agriculture.; History and evolution, from traditional farming to Green Revolution and post-Green Revolution challenges; Global and Indian perspectives on food security. **1.2.** Role of biodiversity, ecosystem services, and agroecology; Role of microbes, composting, green manures, biofertilizers; Soil microbiome and Plant–Microbe interactions, role of endophytes, rhizobia, and mycorrhiza in sustainable farming; Nutrient cycling and Biogeochemical processes - nitrogen fixation, phosphorus solubilization; carbon sequestration in agroecosystems. **1.3.** Soil health, fertility management, and conservation strategies; Organic farming: principles, certification, benefits and limitations; Conservation tillage, crop rotation, agroforestry; Agroecological Indicators, landscape-level biodiversity indices, pollinator diversity, soil biodiversity as sustainability metrics.; Indicators of agricultural sustainability; UN SDGs and agriculture.	**15**	CO1, CO2	K2, K3
Module 2:	**Smart Agriculture, Innovations, and Policies** **2.1.** Climate change impacts on agriculture, mitigation and adaptation strategies; Sustainable resource use and circular bioeconomy; Farmer innovations and indigenous knowledge; Water conservation, watershed management, rainwater harvesting, Integrated Nutrient Management (INM); Integrated Pest Management (IPM). **2.2.** Role of ICT, AI, and remote sensing in sustainable farming; Precision farming and smart agriculture technologies; GM crops, molecular breeding, and biotechnology for sustainability; **2.3.** Policy perspectives: international conventions (UNFCCC, FAO) and Indian initiatives (National Mission on Sustainable Agriculture, organic farming missions); Agri-entrepreneurship farm-to-market linkages, cooperatives, sustainable business models; Carbon Farming and Payment for ecosystem services (PES), credits for carbon	**15**	CO3, CO4	K4, K5

	sequestration and biodiversity conservation; Urban and Peri-Urban Agriculture, rooftop farming, vertical farming for sustainable cities.			
Pedagogy:	Lectures/ICT tools/Group discussions and seminars/Assignments/Field visits.			
Texts:	1. **Altieri, M. A.** (2018) Agroecology: The Science of Sustainable Agriculture (3rd ed.). CRC Press. 2. **Altieri, M. A., & Nicholls, C. I.** (2020) Ecological Intensification of Agriculture: Sustainable Pest Management and Resilient Crop Production. Springer. 3. **Francis, C. A., Lieblein, G., Gliessman, S., Breland, T. A., Creamer, N., Salomonsson, L., Helenius, J., & Wale, P.** (2003) Agroecology for Sustainable Agriculture. CRC Press. 4. **Gliessman, S. R.** (2014) Agroecology: The Ecology of Sustainable Food Systems (3rd ed.). CRC Press. 5. **Lampkin, N., Measures, M., Padel, S., & Foster, C.** (2015) Organic Farming: Science and Practice. CABI. 6. **Pretty, J.** (2018) Sustainable Agriculture and Food. Routledge. 7. **Uphoff, N.** (2019) Agroecological Innovations: Increasing Food Production with Participatory Development. Routledge. 8. **Tittonell, P., & Giller, K. E.** (2013) Sustainable Intensification of Agriculture: From Principles to Practice. Springer.			
References/ Readings:	1. **Altieri, M. A., & Nicholls, C. I.** (2017) The adaptation and mitigation potential of traditional agriculture in a changing climate. Climatic Change, 140, 33–45. 2. **Choudhary, M., Kumar, A., & Singh, R.** (2021) Smart farming technologies for sustainable agriculture: A review. Journal of Cleaner Production, 285, 124941. 3. **Kaur, S., Manchanda, P., & Kaur, G.** (2022) Recent advances in nanotechnology applications in agriculture for sustainable crop production. Frontiers in Plant Science, 13, 946894. 4. **Mahlein, A. K.** (2016) Plant disease detection by imaging sensors – Parallels and specific demands for precision agriculture. Plant Disease, 100(2), 241–251. 5. **Pandey, S., Singh, A., & Tiwari, R.** (2021) Hydroponics: A modern technology for smart agriculture. Sustainable Agriculture Reviews, 50, 133–151. 6. **Pretty, J., Benton, T. G., Bharucha, Z. P., Dicks, L. V., Flora, C. B., Godfray, H. C. J., … Wratten, S.** (2018) Global assessment of agricultural system redesign for sustainable intensification. Nature Sustainability, 1, 441–446.			

	7. **Reddy, A. R., & Reddy, M. K.** (2019) Recent trends in climate-smart agriculture. Current Opinion in Environmental Sustainability, 40, 56–61. 8. **Srivastava, P., Singh, R., Tripathi, S., & Tewari, R.** (2021) Precision agriculture technologies for sustainable farming: A review. Agronomy, 11(9), 1730. 9. **Verma, S., & Singh, S. P.** (2020). Controlled environment agriculture for food security and climate change resilience. Environmental Sustainability, 3, 203–210.
Web Resources:	1. http://www.fao.org/sustainability 2. https://ccafs.cgiar.org 3. https://www.unep.org/resources 4. https://icar.org.in

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Title of the Course	Aquatic Plant Resources and its Conservation
Course Code	BOT-6205
Number of Credits	2
Theory/Practical	Theory
Level	500
Effective from AY	2026-27
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	Yes

Pre-requisites for the Course:	Students should have undergone 400 level courses.	
Course Objectives:	• Understand the ecological and economic significance of aquatic plants. • Explore the utilization of aquatic plants in food, medicine, industry, and biotechnology. • Develop knowledge of conservation strategies for sustainable management of aquatic vegetation.	
Course Outcomes:	Students will be able to:	**Mapped to PSO**
	CO 1. Describe the diversity, distribution, and ecological significance of aquatic plant resources.	PSO 1, PSO 2
	CO 2. Explain the physiological and structural adaptations of aquatic plants to freshwater, estuarine, and marine environments.	PSO 1, PSO 2
	CO 3. Analyze the economic and industrial applications of aquatic plants.	PSO 1, PSO 4
	CO 4. Evaluate the threats posed by overexploitation, invasive species, and climate change on aquatic vegetation.	PSO 2, PSO 4

	CO 5. Apply principles of conservation biology to suggest sustainable management strategies for aquatic plant resources.		PSO 4	
Content:		**No. of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	1.1. Aquatic Plant Diversity and Ecology: Aquatic macrophytes: types and adaptations. Algal diversity and ecological roles; Phytoplankton dynamics and primary productivity; Mangroves, seagrasses, and salt marshes as plant resources; Adaptations of aquatic plants to submerged, emergent, and floating life; Global and regional distribution of aquatic vegetation. 1.2. Algal Resources: Seaweed resources: agar, carrageenan, alginates; Microalgae in nutraceuticals, biofuels, and bioremediation; Role of algae in carbon sequestration and climate resilience. 1.3. Macrophyte and Mangrove Resources: Economic uses of aquatic macrophytes (Eichhornia, Nelumbo, Typha); Mangroves: timber, tannins, medicines, ecological services; Seagrasses; ecosystem services, bioindicators, and carbon sinks; Wetland vegetation in traditional and modern uses. 1.4. Utilization of Aquatic Plants**:** Food and fodder value; pharmaceuticals, cosmetics, and fertilizer industries; bioindicators of pollution; wastewater treatment; constructed wetlands; traditional medicine and bioremediation; Integrated use of aquatic resources for livelihoods.	**15**	CO 1, CO 2, CO 3	K1, K2, K3, K4
Module 2:	2.1. Plant–Environment Interactions: Influence of abiotic factors namely light, nutrients, pH, salinity, temperature, oxygen on aquatic plants; Nutrient cycling and role of aquatic vegetation in C and N dynamics; Plant responses to aquatic pollution and stress (heavy metals, eutrophication); Role of aquatic vegetation in maintaining water quality. Wetlands in Goa, Mangrove ecosystems in Goa, Nesting zones for turtles.	**15**	CO 2, CO 3, CO 4, CO 5	K1, K2, K3

	2.2. Threats to Aquatic Plant Resources: Over-exploitation and habitat degradation; Invasive aquatic plants and their ecological impacts; Pollution, eutrophication, and climate change effects on resources; Case studies of resource decline (coral reef algae, mangroves, seagrasses). 2.3. Conservation and Management: In situ conservation: Wetland conservation and Ramsar sites; mangrove and seagrass restoration; Ex situ conservation: tissue culture, germplasm banks, seed storage; Community participation and traditional knowledge in conservation Marine Protected Areas (MPAs); Use of remote sensing and GIS in aquatic plant and resource monitoring.			
Pedagogy:	Lectures/Tutorials/ ICT-Tools /Group Discussions/Assignments/Seminars.			
Texts:	1. **Allan, J. D., & Castillo, M. M.** (2007) *Stream Ecology: Structure and Function of Running Waters (*2nd ed.). Springer. 2. **Nybakken, J. W., & Bertness, M. D.** (2004) *Marine Biology: An Ecological Approach* (6th ed.). Benjamin Cummings.			
References/ Readings:	1. **Boyd, C. E.** (2015) *Water Quality: An Introduction* (2nd ed.). Springer. 2. **Chapman, V. J., & Chapman, D. J.** (1980) Seaweeds and Their Uses (3rd ed.). Springer. 3. **Kathiresan, K., & Bingham, B. L.** (2001) Biology of mangroves and mangrove ecosystems. Advances in Marine Biology, 40, 81–251. 4. **Wetzel, R. G.** (2001) Limnology: Lake and River Ecosystems (3rd ed.). Academic Press. 5. **FAO.** (2021) Seaweeds and Microalgae: An Overview for Food and Agriculture. FAO. 6. **Santhanam, R.** (2019) Aquatic Plants and Their Utilization. CRC Press.			
Web Resources:	1. appliedaquaticmgmt.com/learning-center/species-database 2. www.aslo.org/online-media-library/online-media-library-plant-life			

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Title of the Course	Soil Science
Course Code	BOT-6206
Number of Credits	3
Theory/Practical	Theory
Level	500
Effective from AY	2026-27
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	Yes

Pre-requisites for the Course:	Students should have undergone 400 level courses.	
Course Objectives:	• Understand the physical, chemical, and biological properties of soils and their influence on plant growth. • Analyze soil fertility, nutrient management, and amendments for crop productivity. • Examine soil-water relationships, erosion, and conservation practices.	
Course Outcomes:	Students will be able to:	**Mapped to PSO**
	CO 1. Understand the processes of soil formation and classify soils based on their physical and chemical properties.	PSO1
	CO 2. Demonstrate knowledge of soil nutrients, fertility evaluation methods, and management practices for crop production.	PSO1, PSO4
	CO 3. Analyze the role of soil microorganisms in nutrient cycling and sustainable soil health management.	PSO2, PSO4

	CO 4. Evaluate soil degradation issues and propose conservation and sustainable management strategies.		PSO2, PSO4	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	1.1. Introduction to Soil Science: Scope, and importance of soil science; Soil as a natural body: soil profile and horizons; Soil forming factors: parent material, climate, organisms, relief, and time; Processes of soil formation (weathering and pedogenesis). 1.2. Soil Physical Properties: Soil texture: classification, particle size distribution, soil textural triangle; Soil structure: types, aggregation, significance; Soil density: particle density, bulk density, porosity; Soil colour and consistency; Soil temperature and its significance; Soil air and soil water: forms, movement, and availability to plants. 1.3. Soil Chemistry: Soil colloids: types (clay and humus), properties, ion exchange; Soil pH, acidity, alkalinity, and buffering capacity; Soil salinity and sodicity: causes, effects, and reclamation.	**15**	CO 1, CO 2	K1, K2, K3, K4
Module 2:	2.1. Soil Fertility and Management: Concept of soil fertility and productivity; Factors affecting soil fertility; Methods of soil fertility evaluation; Soil amendments: lime, gypsum, organic manures, compost, vermicompost, and green manures; Integrated nutrient management (INM). 2.2. Soil Organic Matter: Composition and importance of soil organic matter, Humus: formation, properties and functions, Carbon–Nitrogen ratio (C:N ratio), Soil organic matter and its role in soil fertility; Essential plant nutrients: classification, functions, and deficiency symptoms. 2.3. Soil Biology: Soil organisms: Microflora (bacteria, fungi, actinomycetes, algae), Soil fauna (protozoa, nematodes, earthworms); Role of microorganisms in nutrient cycling, Rhizosphere and its significance, Biological nitrogen fixation (symbiotic and non-symbiotic).	**15**	CO 1, CO 2, CO 3, CO 4	K1, K2, K3, K4

Module 3:	3.1. Soil Classification and Survey: Principles of soil classification, Soil taxonomy (USDA system): order, suborder, great group, Major soil orders of India, Soil survey and mapping, Land capability classification, Soil degradation and conservation. 3.2. Soil Pollution and Environmental Aspects: Soil pollution: causes, sources, types and effects, Heavy metal contamination, Pesticides and their impact on soil health, Industrial and municipal waste disposal, Soil remediation and reclamation, Role of soil in environmental protection. 3.3. Soil Conservation and Sustainable Management: Soil erosion: causes, types, and control measures; Soil conservation techniques; Soil pollution management; Soil health, sustainable agriculture; Recent advances in soil science: Nanotechnology, Soil sensors, Precision farming applications.	**15**	CO 1, CO 2, CO 3, CO 4	K1, K2, K3, K4
Pedagogy:	Lectures/ Tutorials/ICT tools/Assignments/Seminars			
Texts:	1. Alexander, M. **(1999)** *Introduction to Soil Microbiology*. 2nd Ed, Wiley Eastern. 2. Brady, N.C., & Weil, R.R. **(2017)** *The Nature and Properties of Soils*. 15th Ed, Pearson Education. 3. Buol, S.W., Southard, R.J., Graham, R.C., & McDaniel, P.A. **(2011)** *Soil Genesis and Classification.* 6th Ed, Wiley-Blackwell. 4. Donahue, R.L., Miller, R.W., & Shickluna, J.C. **(1990)** *Soils: An Introduction to Soils and Plant Growth.* 5th Edition, Prentice Hall. 5. Tisdale, S.L., Havlin, J.L., Nelson, W.L., & Beaton, J.D. **(1999)** *Soil Fertility and Fertilizers.* 6th Edition, Prentice Hall.			
References/ Readings:	1. Brady, N.C. **(1990)** *The Nature and Properties of Soils.* Macmillan Publishing Company. 2. Brady, N.C., & Weil, R.R. **(2016)** *The Nature and Properties of Soils.* 15th Ed, Pearson Education. 3. Hillel, D. **(2008)** *Soil in the Environment: Crucible of Terrestrial Life.* Academic Press. 4. Indian Society of Soil Science (ISSS) *Handbook of Soil Science* (Latest edition). 5. Miller, R.W. & Gardiner, D.T. **(2007)** *Soils in Our Environment.* 11th Edition, Pearson Prentice Hall. 6. Tan, K.H. **(2010)** *Principles of Soil Chemistry*. 4th Edition, CRC Press. 7. Troeh, F.R., & Thompson, L.M. **(2005)** *Soils and Soil Fertility*. 6th Edition, Wiley-Blackwell 8. Wild, A. **(2003)** *Soils, Land and Food: Managing the Land during the Twenty-First Century*. Cambridge University Press.			

Web Resources:	1. https://open.umn.edu/opentextbooks/textbooks/introduction-to-soil-science 2. https://libguides.kean.edu/c.php?g=884044&p=6851980&utm 3. https://soilweb.ca/?utm 4. https://cottonwood.k-state.edu/news_media/stacy_2020_newscolumns/Free%20online%20book%20on%20soil%20and%20water%20conservation%20resources%20now%20available.pdf?utm 5. https://www.soils.org/?utm

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Title of the Course	Ancient Treatises on Plant Science and Practices
Course Code	BOT-6207
Number of Credits	2
Theory/Practical	Theory
Level	500
Effective from AY	2026-27
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	Yes

Pre-requisites for the Course:	Students who have undergone 400-level courses from any discipline having basic knowledge in plant sciences.	
Course Objectives:	• Familiarize students with ancient Indian and cross-cultural textual traditions that shaped early plant sciences. • Introduce Ayurvedic, Vrikshayurveda, and other classical treatises highlighting medicinal, agricultural, and ecological knowledge. • Develop insights into traditional plant-based practices, rituals, and their scientific relevance. • Bridge ancient wisdom with modern plant sciences, agroecology, pharmacognosy, and sustainability. • Encourage critical thinking about conservation ethics, sustainable use of resources, and policy implications of traditional knowledge.	
Course Outcomes:	Students will be able to:	**Mapped to PSO**
	CO 1. Explain the botanical concepts and cultural significance of plants in Vedic, Ayurvedic, and classical treatises.	PSO 1

	CO 2. Analyse agricultural and ecological practices (soil, irrigation, forest management, groves) described in ancient texts and compare them with modern ecology.		PSO 2	
	CO 3. Interpret pharmacognostic and therapeutic applications of plants from treatises and correlate them with modern phytochemistry and pharmacology.		PSO 1, PSO 2	
	CO 4. Evaluate ecological ethics and socio-cultural practices (sacred groves, rituals, Ahimsa) as models for sustainability and conservation.		PSO 2, PSO 4	
	CO 5. Assess the relevance of traditional knowledge for contemporary challenges in agriculture, herbal industries, bioprospecting, and IPR frameworks.		PSO4	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	**Historical Roots and Textual Traditions in Plant Science** **1.1. Early Botanical Thought in Indian Knowledge Systems (IKS)** • Plants in the Vedas, Upanishads, and Puranas – cosmological, medicinal, and ritual roles. • Concept of "*Oshadhi-sukta*" and sacred plant hymns. • Symbolism of plants in mythology: Soma, Peepal, Neem, and Tulsi. **1.2. Ayurvedic Treatises and Medicinal Plant Science** • *Charaka Samhita*: classification of drugs, *rasa–guna–virya–vipaka* (phytochemical and pharmacological equivalents). • *Sushruta Samhita*: surgical herbs, wound healing plants, formulations. • Plant-based *rasayana* (rejuvenative) therapies and dietary plants. **1.3. Agricultural and Ecological Wisdom in Classical Texts** • *Vrikshayurveda* (Surapala, Kashyapiya Krishi Sukti): soil classification, irrigation, fertilizers, pest control. • Concepts of seed priming, grafting, plant propagation in ancient texts. • *Arthashastra*: forest management, plant-based industries (fibres, dyes, oils). • Sacred groves and their mention in texts as conservation models.		**15**	CO 1, CO 2	K1, K2, K4

	1.4. Other Classical and Regional Texts • Contributions of Buddhist (Jataka tales) and Jain texts to plant ethics and classification. • South Indian contributions: Agathiyar texts, Sangam literature and medicinal flora. • Cross-cultural linkages: Greek, Roman, Chinese parallels to Indian plant sciences. • Early commentaries and translations that spread Indian botanical knowledge globally.			
Module 2:	**Ancient Practices, Scientific Insights, and Modern Relevance** **2.1. Traditional Practices and Applied Botany** • Traditional cropping patterns: intercropping, crop rotation, organic manures. • Use of plants in rituals, festivals, and socio-cultural sustainability. • Ancient knowledge of plant propagation: cuttings, layering, grafting, and tissue concepts in early form. **2.2. Pharmacognosy and Herbal Practices** • Formulation principles of herbal medicines in ancient treatises. • Preparation of churnas, kwathas, lepas, and tailas – modern correlation with pharmacognosy. • Case studies: Neem, Turmeric, Ashwagandha, *Aloe vera* in ancient and modern contexts. **2.3. Ecological and Environmental Ethics** • Sacred groves as biodiversity conservation units in texts. • Concepts of *pancha-mahabhuta* and ecological balance. • *Ahimsa* and plant ethics in Jain and Buddhist thought. • Ancient water management and its role in sustainable plant growth. **2.4. Ancient Wisdom and Modern Innovations** • Comparative taxonomy: ancient plant classification vs. modern systematics. • Relevance of traditional agriculture in climate-smart farming.	**15**	CO 3, CO 4, CO 5	K3, K4, K5, K6

	• Link to modern bioprospecting, nutraceuticals, and herbal industries. • Policy and IPR concerns in using traditional knowledge (TKDL, WIPO). • Emerging frontiers: bridging *Vrikshayurveda* with agroecology, biotechnology, and sustainability sciences.			
Pedagogy:	Lectures, Concept-based Assignments, Critical Reading, ICT tools, Peer Discussions, Seminars.			
Texts:	1. **Amritpal, Singh.** (Translator) (2008) or Prof. Anugrah Narain Singh (Editor/Translator) (2022) Dhanvantari Nighaṇṭu, Chaukhambha Orientalia (Chaukhamba Sanskrit Pratishthan), India. 2. **Bhishagratna, K. L.** (1907-1918) An English Translation of the Sushruta Samhita (3 Volumes, Original Sanskrit Text by Sushruta), Various later reprints exist (e.g., 1991), Chaukhamba Orientalia / Indian National Science Academy (INSA), India. 3. **Sadhale, N.** (Editor & Translator) (1996) Surapala's Vrikshayurveda (Original Sanskrit Text by Surapala), Asian Agri-History Foundation, India. 4. **Sircar, N. N., & Sarkar Roma** (1998/2007) Vrksayurveda of Parasara: A Treatise on Plant Science (Original Sanskrit Text attributed to Parasara), 2nd Ed (2007) or earlier editions, Asian Agri-History Foundation / Indian National Science Academy (INSA), India. 5. **Sharma, Priya. Vrat.** (1981) Caraka Samhita (4 Volumes, Sanskrit Text with English Translation), Chaukhamba Orientalia, India. 6. **Srikantha Murthy K. R.** (Translator) (2016) Bhāvaprakāśa Nighaṇṭu (*Part of Bhāvaprakāśa by Bhāva Miśra*), Chaukhambha Orientalia (Two Volumes), India. 7. **Majumdar, G. P.** (1927) Vanaspati: Plants and Plant-Life as in Indian Treatises and Traditions, Calcutta University Press, India. 8. **Panchmukhi, A. R.** (2016) Dictionary of Sanskrit Quotations on Botany and Horticulture in Ancient India, Karnataka Historical Research And National Institute of Vedic Science (NIVST), India.			
References/ Readings:	1. **Botanicus**, H. Scientific methods for identification of plants mentioned in ancient texts (as exemplified by biblical phytonymics). 2. **Chattopadhyaya**, D. (1978) Science and society in ancient India (Vol. 22). John Benjamins Publishing. 3. **Chaudhary, R., Darji, Y., & Kachchhava, K.** (2025) Organic Farming and the Agricultural Wisdom of Ancient India: An Exploration of Sustainable Agroecology. Agriculturae Conspectus Scientificus, 90(1), 1-6. 4. **Gupta**, S. M. (2024) Plant myths and traditions in India. Brill.			

	5. **Hardy, G., & Totelin, L.** (2015) Ancient botany. Routledge. 6. **Jha, A. K., & Sahay, S.** (Eds.). (2023) Aspects of science and technology in ancient India. Taylor & Francis. 7. **Yaniv, Z.** (2014) Introduction: Medicinal plants in ancient traditions. In Medicinal and Aromatic Plants of the Middle-East (pp. 1-7). Dordrecht: Springer Netherlands.
Web Resources:	https://niimh.nic.in/ebooks/e-Nighantu/?mod=home&con=pf

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Title of the Course	Plant Animal Interactions
Course Code	BOT-6208
Number of Credits	4
Theory/Practical	Theory
Level	500
Effective from AY	2026-27
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	Yes

Pre-requisites for the Course:	Students who have undergone 400-level courses in biological sciences.	
Course Objectives:	• Provide comprehensive knowledge of the diversity, evolution, and ecological significance of plant–animal interactions. • Explain the mechanisms underlying pollination, seed dispersal, herbivory, and specialized interactions. • Develop critical understanding of the adaptive strategies, co-evolution, and ecological networks governing biodiversity. • Evaluate the impact of anthropogenic pressures, invasive species, and climate change on plant–animal interactions. • Relate plant–animal interactions to conservation, ecosystem services, and sustainable ecological management.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Describe the types, diversity, and evolutionary basis of plant–animal interactions.	PSO 1

	CO 2. Analyse the ecological and evolutionary mechanisms in pollination biology, seed dispersal, and ant–plant associations.		PSO 2	
	CO 3. Critically evaluate the role of herbivory, co-evolutionary arms races, and multi-trophic interactions in shaping biodiversity.		PSO 2	
	CO 4. Interpret the ecological significance of specialized interactions (carnivory, symbioses) and plant communities as habitats.		PSO 1, PSO 2	
	CO 5. Assess the effects of anthropogenic pressures, invasive plants, and climate change on plant–animal interaction networks.		PSO 2, PSO 4	
	CO 6. Relate plant–animal interactions to ecosystem services, conservation biology, and sustainable management strategies.		PSO 2, PSO 4	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	**Diversity and Evolutionary Basis of Plant–Animal Interactions** **1.1.** Types of interactions: Mutualism, Antagonism, Commensalism, Competition, Facilitation. **1.2.** Multi-trophic level interactions; species interactions and the evolution of biodiversity. Co-evolution and co-speciation of plants and animals; adaptive radiation. **1.3.** Evolutionary history of interactions and evidence in the geological past. **1.4.** Principle of allocation; Herbivores and green plants: Nutritional requirements of insects, seasonal and temporal distribution of nutrients in plant parts. Herbivory vs plant fitness, herbivore efficiency and ecosystem dynamics. Effect of herbivores on plant communities – Janzen-Connell hypothesis. **1.5.** Co-evolutionary arms race: plant defence (physical, chemical, 'third party' defences) and animal responses (behavioural, detoxification, conjugation, target-site insensitivity, excretion). **1.6.** Hormonal interactions between plants and animals; hormone signalling in trophic interactions; animal pheromones and defence substances. Introduction to network	**20**	CO 1, CO 3, CO 4	K1, K2, K4, K5

	ecology: ecological networks, modularity, nestedness, robustness, resilience in interaction webs.			
Module 2:	**Pollination, Seed Dispersal, and Specialized Interactions** **2.1.** Pollination biology: Importance of cross-pollination. Evolutionary origin and early diversification of animal pollination. **2.2.** Special differentiation associated with pollinator attraction – advertisement and reward (pollen, nectar, elaiophores, resin glands, osmophores, optical displays, and visual cues). **2.3.** Floral adaptation to different pollinators – insects (Hymenoptera, Diptera, Coleoptera, Lepidoptera, Thysanoptera), birds, bats, and non-flying animals. **2.4.** Sapromyiophily, brood-site pollination; fig–wasp interaction. **2.5.** Pollination biology and gene flow: foraging theory, foraging strategies, time-niche strategies. **2.6.** Fruits, seeds, and dispersal agents: plant adaptations – fruit chemistry (chemical compartmentalization, pulp vs seed, nutritional aspects, palatability inhibitors, toxins). **2.7.** Seed coat, seed toxins, phenology, signals, fruit size, and fruit production. Range of seed dispersers, seed shadows, frugivores as foragers, seed predators. **2.8.** Animal adaptations for dispersal – external and internal morphology, digestive physiology, behaviour. Factors limiting reciprocal plant–animal specialization. **2.9.** Ant–plant interactions: origin and early evolution. **2.10.** Ant–plant symbioses (mutualistic and non-mutualistic: herbivores, harvesting ants, granivores, leaf-cutting). Ants as seed dispersers and pollinators; direct and indirect associations; ant-fed plants, ant gardens, canopy ants. Fungus-growing ants. Molecular cues and signalling in pollination and seed dispersal.	**20**	CO 2, CO 3, CO 4	K3, K4, K5

Module 3:	**Specialized Plant–Animal Interactions, Communities, and Global Change** **3.1.** Carnivorous plants: trap mechanisms, interactions with animals, nutritional benefits, cost–benefit analysis, evolutionary pathways to carnivory. **3.2.** Plant communities as animal habitats: adaptations, ecological segregation, mechanisms of habitat selection, habitat selection theory. **3.3.** Plant resource characteristics and animal population dynamics; effects of plants on animal spacing and aggression. Animal diversity in relation to plant resources. **3.4.** Impact of invasive plants on native plant–animal interactions. Plant–animal interactions in agricultural ecosystems (pollination, seed dispersal, herbivory, biocontrol). Conservation aspects of plant–animal interactions. **3.5.** Climate change and breakdown of plant–animal interactions: impacts on community structure, biodiversity, productivity, and human livelihood. Anthropogenic drivers: habitat loss, fragmentation, pesticides, urbanization, light/noise pollution. Plant–animal interactions in ecosystem services (pollination economics, seed dispersal networks, carbon storage). Restoration ecology and assisted pollination/dispersal under global change.	**20**	CO 4, CO 5, CO 6	K4, K5, K6
Pedagogy:	Lectures, Interactive Tutorials, Concept-based Assignments, ICT tools, Peer Discussions, Field observations, Seminars.			
Texts:	1. **Abrahamson, W. G.** (ed.) (1989) Plant-animal interactions. McGraw-Hill Book Company, NY. 2. **Burslem, D., M. Pinard., & S. Hartley. (**2005) Biotic Interactions in the Tropics: Their Role in the Maintenance of Species Diversity. Cambridge University Press. 3. **Crawley, M. J.** (1986) Plant Ecology. Blackwell Scientific Publications. 4. **Del-Claro, K., & Torezan-Silingardi, H.M.** (2021) Plant-animal interactions. Springer International Publishing, Switzerland. 5. **Endress, P. K. (**1994) Diversity and Evolutionary biology of tropical flowers. Cambridge University Press. 6. **Harborne, J. B. (**1988) Introduction to ecological biochemistry. Academic Press.			

	7. **Herrera, Carlos. M., & Olle, Pellmyr.** (eds.). (2002) Plant Animal Interactions: An Evolutionary Approach. Blackwell Science. 8. **Holldobler, B., & Wilson, E. O. (**1990) The Ants. Springer-Verlag. 9. **Keshamma, E., & Lokare, P.** (2022) Plant Animal Interaction. Book Saga Publications, US. 10. **Lloyd, D. G., & Barret, S.C. H. (**1996) Floral Biology: Studies on Floral evolution in Animal pollinated plants. Chapman and Hall. **11. Price, P. W., T.M. Lewinsohn, G.W. Fernandes., & W.W. Benson. (**1991) Plant-Animal Interactions: Evolutionary Ecology in Tropical and Temperate Regions. A Wiley-Interscience publication 12. **Proctor, M., Yeo, P., & Lack, A.** (1996) The Natural History of Pollination. Harper Collins Publishers. 13. **Richards, A. J. (**1986) Plant Breeding systems. George Allen and Unwin, London. 14. **Schaefer, M.H., & G.D. Ruxton.** (2011) Plant-Animal Communication. Oxford University Press. 15. **Seckbach, J., & Z. Dubinsky.** (2010) All Flesh Is Grass: Plant- Animal Interrelationships. Springer Science and Business Media. 16. **Simberloff, D.** (2022) Concise, comprehensive reviews of how invasive plants interact with plants, animals, and microbes. Biological invasions, Springer. 17. **Smith, R. L.** (1990) Ecology and field biology. Harper and Row Publishers, New York. 18. **Waser, N.M., & J. Ollerton.** (2006) Plant-Pollinator Interactions: From Specialization to Generalization. University of Chicago Press. 19. **Whitmore, T. C.** (1990) An introduction to tropical rain forests. Clarendon Press, Oxford. 20. **Willmer, Pat.** (2011) Pollination and Floral Ecology. Princeton University Press.
References/ Readings:	1. **Del-Claro, K., & Torezan-Silingardi, H. M.** (2021) An evolutionary perspective on plant-animal interactions. In *Plant-animal interactions* (pp. 1-15). Springer, Cham. 2. **Cutter, A. D.** (2025) Interspecies reproductive interactions and the evolution of plant and animal mating systems. A commentary on. Journal of Evolutionary Biology, 38(6), 696-701. 3. **Guo, S., Cui, L., Xu, J., Liu, M., Wang, W., Xia, A., & Cui, X.** (2025) A global synthesis of plant-plant interaction investigations: current knowledge and future directions. Plant and Soil, 1-12. 4. **Hedrich, R., & Fukushima, K.** (2021) On the origin of carnivory: molecular physiology and evolution of plants on an animal diet. Annual review of plant biology, 72(1), 133-153.

	5. **Procko, C., & Chory, J.** (2024) Carnivorous plant evolution: is a killer defense always the best option?. Journal of Experimental Botany, *75*(1), 9-12. 6. **Preston, J. C., Sinha, N. R., Torii, K. U., & Kellogg, E. A.** (2022) Plant structure and function: Evolutionary origins and underlying mechanisms. Plant Physiology, 190(1), 1-4.
Web Resources:	1. https://www.try-db.org/TryWeb/Home.php 2. https://dbif.brc.ac.uk/homepage.aspx 3. https://www.sussex.ac.uk/lifesci/ebe/dopi/about 4. http://www.ecologia.ib.usp.br/iwdb/resources.html

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Title of the Course	Bioremediation
Course Code	BOT-6209
Number of Credits	2
Theory/Practical	Theory
Level	500
Effective from AY	2026-27
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	Yes

Pre-requisites for the Course:	Basic knowledge of Microbiology, Environmental Biology, and Molecular Biology.	
Course Objectives:	• Introduce students to the principles and mechanisms of bioremediation. • Study microbial, plant-based, and enzymatic approaches for remediation of contaminated environments. • Familiarize students with modern tools and techniques for monitoring and enhancing bioremediation processes.	
Course Outcomes:	Students will be able to:	**Mapped to PSO**
	CO 1. Understand the effectiveness of bioremediation techniques for soil, water, and industrial waste management.	PSO2, PSO3
	CO 2. Analyze environmental contaminants and identify suitable microbial or plant-based strategies for their remediation.	PSO2, PSO4
	CO 3. Apply knowledge of bioremediation principles to design laboratory-scale remediation experiments.	PSO3

	CO 4. Critically assess case studies and propose sustainable bioremediation strategies for specific sites.		PSO2, PSO4	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	**Principles and Mechanisms of Bioremediation** **1.1. Bioremediation:** Scope, importance, and types (*in situ*, *ex situ*); Environmental contaminants: Heavy metals, hydrocarbons, pesticides, industrial effluents; Enzymatic and molecular approaches: Role of enzymes, genetic engineering, biosensors; Monitoring and evaluation: Physico-chemical and molecular methods, effectiveness assessment. **1.2. Microbial bioremediation:** Mechanisms, microbial metabolism, bioaugmentation, biostimulation; Phytoremediation: Mechanisms, hyperaccumulators, rhizoremediation, case studies; Mycoremediation: role of fungi and mushrooms in degrading xenobiotics, dyes, and plastics; Nanobioremediation: nanoparticles and nanomaterials in enhancing microbial and plant-based remediation.	**15**	**CO1, CO2**	**K2, K4**
Module 2:	**Applications of Bioremediation** **2.1. Soil bioremediation:** Petroleum hydrocarbons, pesticides, heavy metals; Water and wastewater bioremediation: Domestic and industrial effluents, microalgae-based remediation; Industrial bioremediation: Textile, tannery, and chemical industries. **2.2**. **Bioreactors and emerging technologies:** Biofilms, immobilized cells, biosurfactants; Environmental policy, sustainability, and future perspectives in bioremediation; Success stories and challenges in bioremediation.	**15**	**CO3, CO4**	**K3, K4**
Pedagogy:	Lectures/Assignments/Seminars/ICT-Tools /Interactive Discussions.			
Texts:	1. **Atlas, R. M., & Hazen, T. C.** (2011) Bioremediation: Applied Microbial Solutions for Real-World Environmental Cleanup. ASM Press. 2. **Cunningham, C. J., & Bending, G. D.** (2012) Microbial Bioremediation: From Mechanisms to Applications. John Wiley & Sons. 3. **Gadd, G. M.** (2010) Microbial Bioremediation: Principles and Applications. Cambridge University Press. 4. **Singh, A., & Ward, O. P. (**2004) Biodegradation and Bioremediation. Springer.			

	5. **Singh, R. P., & Kumar, V.** (2020) Advances in Bioremediation Technologies. Elsevier. 6. **Rittmann, B. E., & McCarty, P. L.** (2001) Environmental Biotechnology: Principles and Applications. McGraw-Hill. 7. **Tyagi, M., & da Fonseca, M. M. R.** (2016) Bioremediation of Environmental Pollutants. CRC Press.
References/ Readings:	1. **Vidali, M.** (2001) Bioremediation. An Overview. Pure and Applied Chemistry, 73(7), 1163–1172. 2. **Ghosal, D., Ghosh, S., Dutta, T. K., & Ahn, Y.** (2016) Current state of knowledge in microbial degradation of polycyclic aromatic hydrocarbons (PAHs): A review. Frontiers in Microbiology, 7, 1369. 3. **Tyagi, M., & Singh, S.** (2018) Bioremediation of heavy metals using microbial biosorbents: A review. Environmental Science and Pollution Research, 25, 11345–11360. 4. **Azubuike, C. C., Chikere, C. B., & Okpokwasili, G. C.** (2016) Bioremediation techniques–classification based on site of application: Principles, advantages, limitations and prospects. World Journal of Microbiology and Biotechnology, 32, 180. 5. **Singh, R., & Singh, R. P.** (2017) Bioremediation: A sustainable approach for restoration of polluted environment. Environmental Technology & Innovation, 8, 107–116.
Web Resources:	https://www.epa.gov/soil-bioremediation

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