JAI NARAIN VYAS UNIVERSITY, JODHPUR SYLLABUS
(Four Year Undergraduate Programme)

[BOTANY]
As Per NEP 2020
Semester I &II Examination Session 2026-2027
Semester III &IV Examination Session 2027-2028
Semester V &VI Examination Session 2028-2029
Semester VII &VIII Examination Session 2029-2030 (Honours)
Semester VII &VIII Examination Session 2029-2030 (Honours with Research)

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SEMESTER I													
NHEQF Level	**Semester***	**Course Type**	**Course Code**	**Course Title**	**L**	**P**	**H/W**	**Total Hours**	**Credits**	**Total Credits**	**CA Marks**	**EoSE Marks**	**M.M.**
4.5	**I**	**MNR**	**08/BOT/MNR/101T**	A. Introduction to Thallophyta (Microbes, Algae, Fungi and Bryophytes)	**L**		4	60	**4**	**4**	**20**	**80**	**100**
4.5		**MNR-P**	**08/BOT/MNR/101P**	Practical for Thallophyta (Microbes, Algae, Fungi and Bryophytes)			4	60	**2**	**2**	**10**	**40**	**50**

SEMESTER II													
NHEQF Level	**Semester***	**Course Type**	**Course Code**	**Course Title**	**L**	**P**	**H/W**	**Total Hours**	**Credits**	**Total Credits**	**CA Marks**	**EoSE Marks**	**M.M.**
4.5	**II**	**MNR**	**08/BOT/MNR/151T**	Introduction to Tracheophyte	**L**		4	60	**4**	**4**	**20**	**80**	**100**
4.5		**MNR-P**	**08/BOT/MNR/151P**	Practical for Introduction to Tracheophyte		P	4	60	**2**	**2**	**10**	**40**	**50**

SEMESTER III													
NHEQF Level	**Semester***	**Course Type**	**Course Code**	**Course Title**	**L**	**P**	**H/W**	**Total Hours**	**Credits**	**Total Credits**	**CA Marks**	**EoSE Marks**	**M.M.**
5	**III**	**MNR**	**08/BOT/MNR/201T**	Taxonomy, Embryology and Economic Botany	**L**	**-**	4	60	**4**	**4**	**20**	**80**	**100**
5		**MNR-P**	**08/BOT/MNR/201P**	Practical for Taxonomy, Embryology and Economic Botany		P	4	60	**2**	**2**	**10**	**40**	**50**

SEMESTER IV													
NHEQF Level	**Semester***	**Course Type**	**Course Code**	**Course Title**	**L**	**P**	**H/W**	**Total Hours**	**Credits**	**Total Credits**	**CA Marks**	**EoSE Marks**	**M.M.**
5	**IV**	**MNR**	**08/BOT/MNR/251T**	Cell Biology and Genetics	**L**	**-**	4	60	**4**	**4**	**20**	**80**	**100**
5		**MNR-P**	**08/BOT/MNR/251P**	Practical for Cell Biology and Genetics		P	4	60	**2**	**2**	**10**	**40**	**50**

SEMESTER V														
NHEQF Level	**Semester***	**Course Type**	**Course Code**	**Course Title**	**L**	**P**	**H/W**	**Total Hours**	**Credits**	**Total Credits**	**CA Marks**	**EoSE Marks**	**M.M.**
5.5	**V**	**MNR**	**08/BOT/MNR/301T**	Plant Ecology and Physiology	**L**	**-**	4	60	**4**	**4**	**20**	**80**	**100**
5.5		**MNR-P**	**08/BOT/MNR/301P**	Practical for Plant Ecology and Physiology		P	4	60	**2**	**2**	**10**	**40**	**50**

SEMESTER VI													
NHEQF Level	**Semester***	**Course Type**	**Course Code**	**Course Title**	**L**	**P**	**H/W**	**Total Hours**	**Credits**	**Total Credits**	**CA Marks**	**EoSE Marks**	**M.M.**
5.5	**VI**	**MNR**	**08/BOT/MNR/351T**	Fundamental Biotechnology	**L**	**-**	4	60	**4**	**4**	**20**	**80**	**100**
5.5		**MNR-P**	**08/BOT/MNR/351P**	Practical for Fundamental Biotechnology		P	4	60	**2**	**2**	**10**	**40**	**50**

SEMESTER VII													
NHEQF Level	**Semester***	**Course Type**	**Course Code**	**Course Title**	**L**	**P**	**H/W**	**Total Hours**	**Credits**	**Total Credits**	**CA Marks**	**EoSE Marks**	**M.M.**
6	**VII**	**MNR (Select any one elective paper)**	**08/BOT/DSE/401T**	Cytogenetics and Plant Breeding	**L**		3	45	**3**	**3**	**15**	**60**	**75**
			08/BOT/DSE/401P	Practical for Cytogenetics and Plant Breeding		P	2	30	**1**	**1**	**5**	**20**	**25**
6			**08/BOT/DSE/402T**	Principle of Plant Pathology	**L**		3	45	**3**	**3**	**15**	**60**	**75**
			08/BOT/DSE/402P	Practical for Advances in Plant Pathology		P	2	30	**1**	**1**	**5**	**20**	**25**
6			**08/BOT/DSE/403T**	Agriculture Microbiology	**L**		3	45	**3**	**3**	**15**	**60**	**75**
			08/BOT/DSE/403P	Practical for Agriculture Microbiology		P	2	30	**1**	**1**	**5**	**20**	**25**
6			**08/BOT/DSE/404T**	Plant Microbes Interaction	**L**		3	45	**3**	**3**	**15**	**60**	**75**
			08/BOT/DSE/404P	Practical for Plant Microbes Interaction		P	2	30	**1**	**1**	**5**	**20**	**25**
6			**08/BOT/DSE/405T**	Microbial Ecology	**L**		3	45	**3**	**3**	**15**	**60**	**75**
			08/BOT/DSE/405P	Practical for Microbial Ecology		P	2	30	**1**	**1**	**5**	**20**	**25**
6			**08/BOT/DSE/406T**	Industrial Microbiology	**L**		3	45	**3**	**3**	**15**	**60**	**75**

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			08/BOT/DSE/406P	Practical for Industrial Microbiology		P	2	30	**1**	**1**	**5**	**20**	**25**
6	**VII**	**MNR (Select elective any one paper)**	**08/BOT/DSE/411T**	Stress Physiology	**L**		3	45	**3**	**3**	**15**	**60**	**75**
			08/BOT/DSE/411P	Practical for Stress Physiology		P	2	30	**1**	**1**	**5**	**20**	**25**
6			**08/BOT/DSE/412T**	Plant Molecular Biology & Biotechnology	**L**		3	45	**3**	**3**	**15**	**60**	**75**
			08/BOT/DSE/412P	Practical for Plant Molecular Biology & Biotechnology		P	2	30	**1**	**1**	**5**	**20**	**25**
6			**08/BOT/MNR/413T**	Plant Systematics	**L**		3	45	**3**	**3**	**15**	**60**	**75**
			08/BOT/MNR/413P	Practical for Plant Systematics		P	2	30	**1**	**1**	**5**	**20**	**25**
6			**08/BOT/MNR/414T**	Plant resources utilization and Conservation	**L**		3	45	**3**	**3**	**15**	**60**	**75**
			08/BOT/MNR/414P	Practical for Plant resources utilization and Conservation		P	2	30	**1**	**1**	**5**	**20**	**25**
6			**08/BOT/MNR/415T**	Nanobiotechnology	**L**		3	45	**3**	**3**	**15**	**60**	**75**
			08/BOT/MNR/415P	Practical for Nanobiotechnology		P	2	30	**1**	**1**	**5**	**20**	**25**
			08/BOT/MNR/416T	Plant Proteomics	**L**		3	45	**3**	**3**	**15**	**60**	**75**
			08/BOT/MNR/416P	Practical for Plant Proteomics		P	2	30	**1**	**1**	**5**	**20**	**25**
									26	26	130	520	650

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SEMESTER VIII													
NHEQF Level	**Semester***	**Course Type**	**Course Code**	**Course Title**	**L**	**P**	**H/W**	**Total Hours**	**Credits**	**Total Credits**	**CA Marks**	**EoSE Marks**	**M.M.**
6	**VIII**	**MNR (Select any one elective paper)**	**08/BOT/DSE/451T**	Modern Trends in Plant Systematics	**L**		3	45	**3**	**3**	**15**	**60**	**75**
			08/BOT/DSE/451P	Practical for Modern Trends in Plant Systematics		P	2	30	**1**	**1**	**5**	**20**	**25**
6			**08/BOT/DSE/452T**	Population Biology	**L**		3	45	**3**	**3**	**15**	**60**	**75**
			08/BOT/DSE/452P	Practical for Population Biology		P	2	30	**1**	**1**	**5**	**20**	**25**
6			**08/BOT/DSE/453T**	Environment Monitoring, Management and Restoration	**L**		3	45	**3**	**3**	**15**	**60**	**75**
			08/BOT/DSE/453P	Practical for Environment Monitoring, Management and Restoration		P	2	30	**1**	**1**	**5**	**20**	**25**
6			**08/BOT/DSE/454T**	Applied in molecular and Biotechnology	**L**		3	45	**3**	**3**	**15**	**60**	**75**
			08/BOT/DSE/454P	Practical for Applied in molecular and Biotechnology		P	2	30	**1**	**1**	**5**	**20**	**25**
6			**08/BOT/DSE/455T**	Crop Genetics and Plant Breeding	**L**		3	45	**3**	**3**	**15**	**60**	**75**
			08/BOT/DSE/455P	Practical for Crop Genetics and Plant Breeding		P	2	30	**1**	**1**	**5**	**20**	**25**
			08/BOT/DSE/456T	Agricultural Biotechnology	**L**		3	45	**3**	**3**	**15**	**60**	**75**
			08/BOT/DSE/456P	Practical for Agricultural Biotechnology		P	2	30	**1**	**1**	**5**	**20**	**25**

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			08/BOT/DSE/457T	Genomics and Bioinformatics	**L**		3	45	**3**	**3**	**15**	**60**	**75**
			08/BOT/DSE/457P	Practical for Genomics and Bioinformatics		P	2	30	**1**	**1**	**5**	**20**	**25**
6													
6	**VIII**	**MNR (Select any one elective paper)**	**08/BOT/DSE/461T**	Advanced Plant Physiology	**L**		3	45	**3**	**3**	**15**	**60**	**75**
			08/BOT/DSE/461P	Practical for Advanced Plant Physiology		P	2	30	**1**	**1**	**5**	**20**	**25**
6			**08/BOT/DSE/462T**	Genetic Engineering of Plants	**L**		3	45	**3**	**3**	**15**	**60**	**75**
			08/BOT/DSE/462P	Practical for Genetic Engineering of Plants		P	2	30	**1**	**1**	**5**	**20**	**25**
			08/BOT/DSE/463T	Phytochemistry and Pharmacognosy	**L**		3	45	**3**	**3**	**15**	**60**	**75**
6			**08/BOTDSE/463P**	Practical for Phytochemistry and Pharmacognosy		P	2	30	**1**	**1**	**5**	**20**	**25**
6			**08/BOT/DSE/464T**	Traditional knowledge and IPR practices in plant science	**L**		3	45	**3**	**3**	**15**	**60**	**75**
			08/BOT/DSE/464P	Practical for Traditional knowledge and IPR practices in plant science		P	2	30	**1**	**1**	**5**	**20**	**25**
6			**08/BOT/DSE/465T**	Biodiversity and Conservation Biology	**L**		3	45	**3**	**3**	**15**	**60**	**75**
			08/BOT/DSE/465P	Practical for Biodiversity and Conservation Biology		P	2	30	**1**	**1**	**5**	**20**	**25**
6			**08/BOT/DSE/466T**	Plant Diseases and their Management	**L**		3	45	**3**	**3**	**15**	**60**	**75**
			08/BOT/DSE/466P	Practical for Plant Diseases and their Management		P	2	30	**1**	**1**	**5**	**20**	**25**
6	**VIII**	**MNR (Select any one elective paper)**	**08/BOT/DSE/471T**	Industrial Botany	**L**		3	45	**3**	**3**	**15**	**60**	**75**
			08/BOT/DSE/471P	Practical for Industrial Botany		P	2	30	**1**	**1**	**5**	**20**	**25**
6			**08/BOT/DSE/472T**	Aquatic Botany	**L**		3	45	**3**	**3**	**15**	**60**	**75**
			08/BOT/DSE/472P	Practical for Aquatic Botany		P	2	30	**1**	**1**	**5**	**20**	**25**

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6			**08/BOT/DSE/473T**	Advances in Mycology	**L**		3	45	**3**	**3**	**15**	**60**	**75**
			08/BOT/DSE/473P	Practical for Advances in Mycology		P	2	30	**1**	**1**	**5**	**20**	**25**
			08/BOT/DSE/474T	Botanical Entrepreneurship	**L**		3	45	**3**	**3**	**15**	**60**	**75**
			08/BOT/DSE/474P	Practical for Botanical Entrepreneurship		P	2	30	**1**	**1**	**5**	**20**	**25**
6			**08/BOT/DSE/475T**	Advanced Tools & Analytical Techniques in Plant Biology	**L**		3	45	**3**	**3**	**15**	**60**	**75**
			08/BOT/DSE/475P	Practical for Advanced Tools & Analytical Techniques in Plant Biology		P	2	30	**1**	**1**	**5**	**20**	**25**
6			**08/BOT/DSE/476T**	Molecular Ecology	**L**		3	45	**3**	**3**	**15**	**60**	**75**
			08/BOT/DSE/476P	Practical for Molecular Ecology		P	2	30	**1**	**1**	**5**	**20**	**25**
				Total					**24**	**24**	**10**	**480**	**600**

- **Columns may be increased according to the requirement.**

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COURSES IN MINOR/ELECTIVE

SEMESTER	COURSE TYPE	COURSE CODE
I	Introduction to Thallophyta (Microbes, Algae, Fungi and Bryophytes)	**08/BOT/MNR/101T**
II	Introduction to Tracheophyte	**08/BOT/MNR/151T**
III	Taxonomy, Embryology and Economic Botany	**08/BOT/MNR/201T**
IV	Cell Biology and Genetics	**08/BOT/MNR/251T**
V	Plant Ecology and Physiology	**08/BOT/MNR/301T**
VI	Fundamental Biotechnology	**08/BOT/MNR/351T**

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MINOR/ELECTIVE (DSE)PAPER

SEMESTER	Course Type		COURSE CODE
VII	**Minor/Elective Course I Group**		
	Select any One Elective Course	Cytogenetics and Plant Breeding	**08/BOT/DSE/401T**
		Principle of Plant Pathology	**08/BOT/DSE/402T**
		Agriculture Microbiology and Biotechnology	**08/BOT/DSE/403T**
		Plant Microbes Interaction	**08/BOT/DSE/404T**
		Microbial Ecology	**08/BOT/DSE/405T**
		Industrial Microbiology	**08/BOT/DSE/406T**
	Minor/Elective Course II Group		
	Select any One Elective Course	A. Stress Physiology	**08/BOT/DSE/411T**
		B. Plant Molecular Biology & Biotechnology	**08/BOT/DSE/412T**
		C. Plant Systematics	**08/BOT/DSE/413T**
		D. Plant resources utilization and Conservation	**08/BOT/DSE/414T**
		E. Fundamentals of Nanotechnology	**08/BOT/DSE/416T**
		F. Plant Proteomics	**08/BOT/DSE/417T**
VIII	**Minor/Elective Course I Group**		
	Select any One Elective Course	A. Modern Trends in Plant Systematics	**08/BOT/DSE/451T**
		B. Population Biology	**08/BOT/DSE/451T**
		C. Environment Monitoring, Management and Restoration	**08/BOT/DSE/452T**
		D. Applied Molecular and Biotechnology	**08/BOT/DSE/453T**
		E. Crop Genetics and Plant Breeding	**08/BOT/DSE/454T**
		F. Agricultural Biotechnology	**08/BOT/DSE/455T**
		G. Genomics and Bioinformatics	**08/BOT/DSE/456T**
	Minor/Elective Course II Group		
	Select any One Elective Course	Advanced Plant Physiology	**08/BOT/DSE/461T**
		Genetic Engineering of Plants	**08/BOT/DSE/462T**
		Phytochemistry and Pharmacognosy	**08/BOT/DSE/463T**
		Traditional knowledge and IPR practices in plant science	**08/BOT/DSE/464T**
		Biodiversity and Conservation Biology	**08/BOT/DSE/465T**
		Plant Diseases and their Management	**08/BOT/DSE/466T**
	Minor/Elective Course III Group		
	Select any One Elective Course	Industrial Botany	**08/BOT/DSE/471T**
		Aquatic Botany	**08/BOT/DSE/472T**
		Advances in Mycology	**08/BOT/DSE/473T**
		Botanical Entrepreneurship	**08/BOT/DSE/474T**
		Advanced Tools & Analytical Techniques in Plant Biology	**08/BOT/DSE/475T**
		Molecular Ecology	**08/BOT/DSE/476T**

VIII	**Research Project/Dissertation (Honours with Research Programme)**	**08/BOT/RP/D/481**

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Four Year Undergraduate Programme (Botany) Syllabus, Semester-I		
Session 2026-2027		
Part-A Introduction		
Subject	**Botany**	
Semester	**I**	
Name of the Course	Introduction to Thallophyta (Microbes, Algae, Fungi and Bryophytes)	
Course Code	**08/BOT/MNR/101T**	
Course Type:	MNR (Minor)	
Level of the course (As per Annexure-I)	100-199	
Foundation or Introductory Courses		
Course Learning Outcomes (CLO)	After completing the course: CLO 1. Understand the diversity, structure, and replication of microbes. CLO 2. Understand diverse form of Alage, Fungi and Bryophyta. CLO 3. Identify the major groups of lower plants with their significances. CLO 4. Understand the life cycle of lower plants. CLO 5. Understand the ecological succession among thallophyta.	
Credits	4+2=6	
Total Marks	20+80=100 Theory and 10+40=50 Practical; Total Marks=150	
Part-B Contents of the Course		
Total lecture per week	4Theory+4Practical=8hr	

Units	**Topics**	**No. of Lecture/Contact Hours (60hr)**
I	General characteristics of Prions and Viroids. Characteristics features of Viruses with life form of TMV. Structure and Multiplication of Bacteriophages. General account and biology of Mycoplasma and Phytoplasma.	12
II	Characteristics features of Eubacteria with reference to structure, replication and economic importance. Characteristics features of Archaebacteria. Characteristics features of Cyanobacteria with life cycle of Nostoc. Nitrogen fixation mechanism of Cyanobacteria.	12
III	General characters and classification of Fungi. Characteristics features of Mastigomycotina, Zygomycotina, Ascomycotine, Basidiomycotina and deuteromycotina. Structure and life cycle of *Albugo*, *Rhizopus*, *Peniclillum*, *Puccinia* and *Alternaria*. Economic importance of Fungi.	12
IV	General Character and Classification of Algae. Characteristics features of Chlorophyceae, Charaophyacea, Phaeophyceae, Rhodpophyceae. Structure and life cycle of *Volvox*, *Chara*, *Ectocarpus* and *Polysiphonia*. Economic importance of Algae. General account of Lichen.	12
V	General Characters and classification of Bryophyta. Characteristics features of Hepaticopsida, Anthocerotopsida and Bryopsida. Structure and life form of *Marchantia*, *Anthoceros* and *Sphagnum*. Economic importance of Bryophyta.	12

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08/BOT/MNR/101P: Practical for Thallophyta (Microbes, Algae, Fungi and Bryophytes)

Credits	Hours	Marks	Total Hr
2	4	10+40=50	60

Laboratory Exercises:

1. Virus: Morphotype of TMV and Bacteriophase (Specimen/Photographs)
2. Phytoplasma and mycoplasma (Specimen/Photographs)
3. Eubacteria: Microscopic preparation and study of Gram staining.
4. Cyanobacteria: Microscopic preparation and study of *Nostoc*.
5. Fungi: Microscopic preparation and study of following fungi: *Albugo, Rhizopus, Penicillium, Puccinia* and *Alternaria.*
6. Algae: Microscopic preparation and study of following alga: *Volvox, Chara, Ectocarpus,* and *Polysiphonia.*
7. Lichen: Study of *Rhizocarpon*, P*armelia* and *Usnea*
8. Bryophyta: Study of external morphology and microscopic preparation of following Bryophytes:
    i. *Marchantia* (External morphology, VTS of thallus through gemma cup, male and female sex organs and sporophyte).
    ii. *Anthoceros* (External morphology, VTS of thallus and sporophyte).
    iii. *Sphagnum* (External morphology and mounting of single leaf).

Recommended Books:

1. Alexopoulos, C.J., and Mims. Introductory Mycology, John Wiley and Sons, New York, 2000.
2. Bilgrami, K.S. and Dube, H.C. A Text Book of Modern Plant Pathology, VikasPubl. House, New Delhi, 1976.
3. Bold, H.C., Alexopolous, C.J. and Delevoryas, T. Morphology of plant and fungi (4th ed.), Harper and Foul, Co., New York, 1980.
4. Dube, H.C. Fungi, Scientific Publisher, 2012.
5. Trivedi. P. C. Bacteriology Structure, Reproduction, Plant Diseases and Management. Nova Science Publishers. 2021.
6. Panday, B.P. Botany- Microbiology and plant pathology. S. Chand. Publication 2022
7. Pandey, S.N. and Trivedi, P.S. A Text Book of Botany Volume I, Vikas Pub. House Pvt. Ltd., New Delhi. 2000
8. Pandey, S.N., Mishra, S.P., Trivedi, P.S. A Text Book of Botany Vol. II, Vikas Pub. House Pvt. Ltd., New Delhi 2000.
9. Raven, P.H. Evert, R.F. and Eichhom, S.C. Biology of plants, (5th ed.), W.H. Reema and Co., Worth Publication, New York, U.S.A., 1999.
10. Sharma, P.D. Microbiology and Plant Pathology, Rastogi Publ. Meerut, 2003.
11. Singh, V., Pande, P.C. and Jain, D.K. A Text Book of Botany, Rastogi & Co., Meerut, 2001.
12. Vashista, B. R. Botany for Degree Students (Algae, Fungi, Bryophyta), S. Chand & Co. Ltd., New Delhi,2002.

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Four Year Undergraduate Programme (Botany) Syllabus, Semester-II		
Session 2026-2027		
Part-A Introduction		
Subject	**Botany**	
Semester	**II**	
Name of the Course	Tracheophyta	
Course Code	08/BOT/MNR/151T	
Course Type:	MNR (Minor)	
Level of the course (As per Annexure-I)	100-199	
Foundation or Introductory Courses		
Course Learning Outcomes (CLO)	After completing the course: CLO1: Understand fundamentals of palaeobotany including fossil types, fossilization processes, and geological time scale. CLO2: Explain structure, life cycles, and key evolutionary features of pteridophytes and gymnosperms. CLO3: Describe origin, evolution, morphology, and classification of angiosperms. CLO4: Apply principles of plant systematics, identification, and nomenclature. CLO5: Analyze plant anatomy including tissues, primary and secondary growth, and anomalous structures.	
Credits	4+2=6	
Total Marks	20+80=100 Theory and 10+40=50 Practical; Total Marks=150	
Part-B Contents of the Course		
Total lecture per week	4Theory+4Practical=8hr	

Units	**Topics**	**No. of Lecture/Contact Hours**
I	**Palaeobotany**: General account on fossils and fossilization; kinds of preservation: compressions, coal balls, impressions, incrustations (Casts), petrifactions (mineralized plants), compactions (Mummified plants), ambers. Geological time scale, computation of age of fossils (radio carbon dating). Economic importance of Fossils. General account of Psilophytales (Rhynia), Lepidodendrales (Lepidodendron), Sphenophyllales (Sphenophyllum) and Bennettittales (Williamsonia).	12
II	**Pteridophytes**. Stelar systems in Pteridophyta. Heterospory and seed habit in Pteridophyta. Important characters of Psilophyta; Structure and life cycle of Psilotum. Important characters of Lycophyta, Sphenophyta and Pterophyta. Structure and life cycle of Lycopodium, Selaginella, Equisetum, Adiantum and Marsilea.	12

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III	General characteristics, classification of gymnosperms. Economic importance of gymnosperms: timber yielding gymnosperms, secondary metabolites from gymnosperms. Important characters of Cycadophyta, Coniferophyta. Morphology, anatomy, reproduction and life cycle of Cycas and Pinus.	12
IV	**Introduction to Angiosperms**: Origin and evolution of angiosperms; Co-evolution of angiosperms and animals; Methods of illustrating evolutionary relationships (phylogenetic tree, cladogram). General characteristics of dicotyledons and monocotyledons, morphology of vegetative and reproductive parts. **Morphology of Angiosperms:** Morphology and types of roots, stem, and leaves phyllotaxy and venation, hairs and trichomes, inflorescence and its types; aestivation. Arrangement and types of reproductive parts of flower, placentation and its types. Introduction to systematics; Plant identification, Classification, Nomenclature.	12
V	Tissues and tissue system: Theories of structural organisation of root apex and shoot apex. Different types of tissue and tissue systems and their functions. Leaf, stem and root anatomy: Leaf anatomy, anatomy of primary monocot and dicot stems/roots, anomalous structure in the primary body of stem. Secondary growth: Secondary and anomalous secondary growth in monocot and dicot stems with special reference to (*Bignonia, Bougainvillea, Amaranthus, Tecoma* and *Dracaena*.)	12

08/BOT/MNR/151P: Practical for Introduction to Tracheophyte

Credits	Hours	Marks	Total Hr
2	**4**	**10+40=50**	**60**

Laboratory Exercises

1. Study of vegetative and reproductive structures of the following taxa through temporary mounts / permanent slides- *Psilotum, Lycopodium, Selaginella, Equisetum, Marsilea* and *Pteris.*
2. Study of vegetative and reproductive structures of the following taxa- Cycas, Pinus, (through temporary mounts / permanent slides).
3. Study of Fossil forms using specimens/slides/photographs – *Rhynia, Lepidodendron, Sphenophylum* and *Williamsonia*.
4. Study of special types of inflorescences – Cyathium, Umbel, Verticillaster.
5. Study of special types of fruits
6. Study of anatomical details of the following through permanent slides/temporary stain mounts/ macerations/specimens with the help of suitable examples: stomatal types, trichomes, xylem and phloem elements.
7. Study of primary structures of monocot and dicot root and stem.
8. Study of anomalous structure in the primary body of stem - *Bougainvillaea, Nyctanthes* and *Oryza*.
9. Study of anomalous secondary growth in Bignonia, Amaranthus, and Dracaena

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Recommended Books:

1. Singh, V., Pande, P.C. and Jain, D.K. A Text Book of Botany, Rastogi & Co., Meerut, 2001.
2. Vashista, P.C., Sinha, A.K., Kumar, A. Gymnosperm, S. Chand & Co. Ltd., New Delhi, 2006.
3. Vashista, P.C., Sinha, A.K., Kumar, A. Pteridophyta, S. Chand & Co. Ltd., New Delhi, 2010.
4. Gifford, E.M. and Foster, A.S. Morphology and Evolution of Vascular Plants, W.H. Freeman and Company, New York, 1988.
5. Pandey, S.N. and Trivedi, P.S. A Text Book of Botany 2000 Volume I, Vikas Pub. House Pvt. Ltd., New Delhi.
6. Sharma, O.P. Pteridophytes, Today and Tomorrow Publication, 2000.
7. Bhatnagar S. P., Moitra Alok (2003) Gymnosperms. New Age International Ltd, New Delhi.
8. Evert, R.F. 2006. Esau's Plant Anatomy: Meristems, Cells, and Tissues of the
9. Plant Body: Their Structure, Function and Development. John Wiley and Sons, Inc Fahn
10. Mauseth, J.D. 1988. Plant Anatomy. The Benjammin/Cummings Publisher, USA.
11. Pandey, B.P. 2001. Plant Anatomy, S. Chand Publishing, New Delhi.
12. Vasistha, P.C. 2000. Plant Anatomy, Pradeep Publications, Jalandhar

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Four Year Undergraduate Programme (Botany) Syllabus, Semester-III	
Session 2027-2028	
Part-A Introduction	
Subject	**Botany**
Semester	**III**
Name of the Course	Taxonomy, Embryology and Economic Botany
Course Code	**08/BOT/MNR/201T**
Course Type:	MNR
Level of the course (As per Annexure-I)	200-299
Intermediate-level Courses	
Course Learning Outcomes (CLO)	After completing the course: CLO1: Describe natural and modern systems of taxonomy and apply rules of plant nomenclature. CLO2: Recognize major plant families and identify plants using keys and diagnostic features. CLO3: Understand plant reproductive biology and analyse embryological processes CLO4: Evaluate economic uses of plants; Relate plant science to agriculture, conservation, and sustainable resource use. CLO5: Perform herbarium techniques, slide preparation, and plant identification in field/lab settings.
Credits	4+2=6
Total Marks	20+80=100 Theory and 10+40=50 Practical; Total Marks=150
Part-B Contents of the Course	
Total lecture per week	4Theory+4Practical=8hr

Units	**Topics**	**No. of Lecture/Contact Hours**
I	Components and objectives of taxonomy; Angiosperm taxonomy -Alpha taxonomy, Omega taxonomy, holotaxonomy; Taxonomic resources: Herbarium, Botanical gardens, Flora	12
II	Principles and rules of Botanical Nomenclature; taxonomic ranks, concept of genus and family; types of classification, Systems of classification– Bentham and Hooker	12
III	Diversity of flowering plants as illustrated by members of the families Papaveraceae, Malvaceae, Apocynaceae, Solanaceae, and Liliaceae	12
IV	Structure of anther and pistil, Structure of Microsporangium, structure of microspore; Structure of Megasporangium or ovule, types of ovules, Structure of mature embryo sac; Brief introduction of Pollination and fertilization, Types of Endosperms	12
V	Uses of Food plants- Wheat, Maize and Peral millets; Fibers- Cotton and Jute, Vegetable oil- Mustard and Groundnut, Beverages: Tea, Medicinal plants- Aloe and Asparagus, General account of source of firewood and timber; Spices: Black pepper, clove, cardamom, turmeric	12

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08/BOT/MNR/201P: Practical for Taxonomy, embryology and economic botany

Credits	Hours	Marks	Total Hr
2	4	10+40=50	60

Laboratory Exercises

1. To prepare at least 2 herbarium specimens and identify them using available resources.
2. Description of taxa using semi-technical terms and identification families- Papavaraceae- Papaver, Malvaceae- Hibiscus, Solanaceae- Datura/ Withania, Liliaceae- Aloe /Lily
3. Study of type of Ovules - anatropous, orthotropous, amphitropous (slides /photos)
4. Study of type of Endosperm- Nuclear, Cellular and helobial (Slides/ photos)
5. Micro-chemical tests to study starch grains of Wheat and rice
6. Detect the presence of cellulose in cotton fibre Pea or ground nut (habit, fruit, seed structure, micro-chemical tests)
7. Detect the presence of Tanin in Tea leaves
8. Detect the presence of oil in Mustard Seed

Recommended Books:

1. Plant Systematics. Arun K. Pandey & Shruti Kansana. 2020. Jaya Publishing House.
2. Bole, P. V. and Vaghani, Y. (1986) Field guide to the common trees of I ndia. Oxford University Press; Bombay.
3. Brandis, D. (1906) Indian Trees (London, 5th edition. 1971). International Book Distributors; Dehra Dun.
4. Dallwitz, M. J., Paine, T. A. and Zurcher, E. J. (2003). Principles of interactive keys. http://delta-intkey.com
5. K. B. Anjaria, (2015)"Electronic Herbarium and Digital Database Preparation of Common Trees of Anand District, Gujarat" MRP submitted to UGC, WRO, Pune 2015 (unpublished)
1. Lizeron Eremias and R. Subash.(2013) "E-Content Development: A Milestone In The Dynamic Progress Of E- Learning" International Journal of Teacher Educational Research (IJTER) Vol.2 No.1 January, 2013 ISSN: 2319- 4642
2. Pandey, B.P. 2007. Botany for Degree Students: Diversity of Seed Plants and their Systematics, Structure, Development and Reproduction in Flowering Plants. S. Chand & Company Ltd,New Delhi.
3. Stace, C. A. 1989. Plant Taxonomy and Biostatistics (2nd Ed.). Edward Arnold, London.
4. Singh, G. 1999. Plant Systematics: Theory and Practice. Oxford and IBH, New Delhi.
5. Dutta A.C. 2016. Botany for Degree Students. Oxford University Press.
6. Davis, P. H. and V. H. Heywood. 1963. Principles of Angiosperm Taxonomy. Oliver and Boyd,London.
7. Heywood, V. H. and D. M. Moore (Eds). 1984. Current Concepts in Plant Taxonomy. Academic Press, London.
8. Bhojwani S.S., Bhatnagar S.P. & Dantu P.K. (2015). The Embryology of Angiosperms, 6th Edition. by Vikas publishing house. ISBN: 978-93259-8129-4.
9. P. Maheshwari, (2004). An introduction to the embryology of Angiosperms. Tata McGraw-Hill Edition, ISBN: 0-07-099434-X.173.
10. Johri, B.M. (1984). Embryology of Angiosperms. Netherlands: Springer-Verlag. ISBN: 13:978-3-642-69304-5
11. Kochhar, S.L. (2011). Economic Botany in the Tropics, MacMillan Publishers India Ltd., New Delhi. 4th edition.
12. Sambamurthy, AVSS & Subrahmanyam, NS (2000). Economic Botany of Crop Plants. Asiatech Publishers. New Delhi.
13. Sharma, OP. 1996. Hill's Economic Botany (Late Dr. AF Hill, adopted by OP Sharma). Tata McGraw Hill Co. Ltd., New Delhi.

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Four Year Undergraduate Programme (Botany) Syllabus, Semester-IV		
Session 2027-2028		
Part-A Introduction		
Subject	**Botany**	
Semester	**IV**	
Name of the Course	Cell Biology and Genetics	
Course Code	**08/BOT/MNR/251T**	
Course Type:	MNR (Minor)	
Level of the course (As per Annexure-I)	200-299	
Intermediate -level Courses		
Course Learning Outcomes (CLO)	After completing the course: CLO1: Explain the cell as the basic unit of life, including cell theory, biomolecules, and differences between prokaryotic and eukaryotic cells. CLO2: Describe the structure and function of cell organelles and principles of microscopy techniques. CLO3: Understand cell division (mitosis and meiosis) and regulation of the cell cycle. CLO4: Analyze chromosome structure, genome organization, linkage, crossing over, and chromosomal variations. CLO5: Explain DNA as genetic material, including replication, transcription, and regulation of gene expression in prokaryotes and eukaryotes.	
Credits	4+2=6	
Total Marks	20+80=100 Theory and 10+40=50 Practical; Total Marks=150	
Part-B Contents of the Course		
Total lecture per week	4Theory+4Practical=8hr	

Units	**Topics**	**No. of Lecture/Contact Hours**
I	The cell unit of life: discovery, concept and cell theory. The chemical basis of life and biological molecules. Prokaryotic and eukaryotic cells. Structural organization of the plant cell, biochemical energetics. cytoskeleton, microtubules and microfilaments.	12
II	Cell wall and plasma membrane: Structure and functions, biogenesis, growth models and functions, sites for ATPases, ion carriers, channels and pumps, receptors. Plasmodesmata: Role in movement of molecules and macromolecules,	12
III	Structure and function: Nucleus: nucleolus, nuclear envelope, nuclear pore complex, nuclear lamina. Cell organelles: mitochondria, plastids, vacuole and peroxisomes, endoplasmic reticulum, Golgi apparatus. Plant vacuole: Structure and function	12
IV	Cell division and regulation of cell cycle; mitosis and meiosis. Genome organization: Chromosome structure and packaging of DNA. Molecular basis of mutation: Spontaneous and induced. Specialized and sex chromosomes; Variation in chromosome number and structure.	12

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	Chromosome theory of inheritance; Linkage, crossing over and chromosome mapping.	
V	DNA the genetic material: experimental proof of DNA as genetic material, DNA structure, replication and transcription (prokaryotes and eukaryotes). Gene expression regulation in prokaryotes and eukaryotes. Introduction to epigenetics	12

08/BOT/MNR/251P: Practical for Cell Biology and Genetics

Credits	Hours	Marks	Total Hr
2	**4**	**10+40=50**	**60**

Laboratory exercise

1. Microscopes
2. Staining
3. Study of plant cell structure with the help of epidermal peel mount of Onion/Rhoeo.
4. Study the phenomenon of plasmolysis.
5. Study different stages of mitosis and meiosis.
4. Karyotype analysis.
6. Chromosome mapping
7. Extraction of DN
8. Quantification of DNA.
9. Amplification of DNA by PCR-demonstration.
10. Agarose electrophoresis
11. DNA -sequencing-dideoxy method-demonstration

Suggesting reading

1. Alberts, B., Johnson, A., Lewis, J., et al. (2014). Molecular Biology of the Cell (6th ed.). ISBN: 978-0815344322. Publisher: Garland Science.
2. Pollard, T. D., Goldman, R. D., & Earnshaw, W. C. (2023). Cell Biology (4th ed.). ISBN: 978-0323758000. Publisher: Elsevier.
3. Klug, W. S., Cummings, M. R., Spencer, C. A., et al. (2023). Concepts of Genetics (13th ed.). ISBN: 978-0136854314. Publisher: Pearson.
4. Hartwell, L. H., Hood, L., Goldberg, M. L., et al. (2021). Genetics: From Genes to Genomes (7th ed.). ISBN: 978-1259921845. Publisher: McGraw Hill.
5. Brooker, R. J. (2023). Genetics: Analysis and Principles (8th ed.). ISBN: 978-1260240892. Publisher: McGraw Hill Education.
6. Lewin, B., Krebs, J. E., Kilpatrick, S. T., & Goldstein, E. S. (2015). Lewin's Genes XII (12th ed.). ISBN: 978-1449659053. Publisher: Jones & Bartlett Learning.
7. Nussbaum, R. L., McInnes, R. R., & Willard, H. F. (2023). Thompson & Thompson Genetics in Medicine (9th ed.). ISBN: 978-0323528001. Publisher: Elsevier.
8. Verma, P. S., & Agrawal, V. K. (2022). Cell Biology, Genetics, Molecular Biology, Evolution & Ecology (12th ed.). ISBN: 978-9389211697. Publisher: S. Chand Publishing.
9. Dalton, L., Young, R., & Ng-Cornish, H. (2023). Fundamentals of Cell Biology. ISBN: 978-1955101387. Publisher: Oregon State University Press (Open Access).
10. Cooper, G. M., & Hausman, R. E. (2023). The Cell: A Molecular Approach (10th ed.). ISBN: 978-0197581483. Publisher: Sinauer Associates / Oxford University Press.
11. Griffiths, A. J. F., Wessler, S. R., Carroll, S. B., & Doebley, J. (2020). Introduction to Genetic Analysis (12th ed.). ISBN: 978-1319284310. Publisher: W.H. Freeman.
12. Snustad, D. P., & Simmons, M. J. (2021). Principles of Genetics (7th ed.). ISBN: 978-1119624223. Publisher: Wiley.
13. Lewis, R. (2022). Human Genetics: Concepts and Applications (13th ed.). ISBN: 978-1260722825. Publisher: McGraw Hill.
14. Falconer, D. S., & Mackay, T. F. C. (2023). Introduction to Quantitative Genetics (4th ed.). ISBN: 978-0582243026. Publisher: Routledge.

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Four Year Undergraduate Programme (Botany) Syllabus, Semester-V	
Session 2027-2028	
Part-A Introduction	
Subject	**Botany**
Semester	**V**
Name of the Course	Plant Ecology and Physiology
Course Code	**08/BOT/MNR/301T**
Course Type:	MNR (Minor)
Level of the course (As per Annexure-I)	300-399
High-Level Courses	
Course Learning Outcomes (CLO)	After completing the course: CLO1: Explain ecosystem structure, function, energy flow, and ecological interactions including food chains, webs, and pyramids. CLO2: Analyze productivity, ecological succession, and changes in ecosystem properties during different successional stages. CLO3: Describe plant water relations, mineral nutrition, and transport processes (transpiration and translocation). CLO4: Understand major physiological and metabolic processes including respiration, photosynthesis, and nitrogen metabolism. CLO5: Evaluate the role of phytohormones and environmental factors in plant growth, development, and movements.
Credits	4+2=6
Total Marks	20+80=100 Theory and 10+40=50 Practical; Total Marks=150
Part-B Contents of the Course	
Total lecture per week	4Theory+4Practical=8hr

Units	**Topics**	**No. of Lecture/Contact Hours**
I	Ecology: Definition, Ecosystem– Concept, structure and function; Abiotic and biotic components, Food chains and food webs, Ecological pyramids; Biogeochemical and hydrological cycles, Energy flow in an ecosystem.	12
II	Productivity and Plant Succession: Productivity concept and types. Primary Productivity-measurement, global pattern and controlling factors. Succession: Concept, kinds, mechanism and models, changes in ecosystem properties during early and late successional stage.	12
III	Plant Physiology: Plant water relation, Mineral Nutrition, Transpiration and translocation; active and passive transport, Carbon Oxidation: Glycolysis, Fermentation, Krebs cycle; Oxidative pentose phosphate pathway, Oxidative phosphorylation, factors affecting respiration.	12
IV	Photosynthesis: Pigments, Cyclic and non-cyclic light reaction, C3, C4 and CAM- carbon fixation and Significance; Photorespiration: process and significance; Translocation of photoassimilates; Phloem transport: pressure flow hypothesis; Phloem loading and unloading	12
V	Nitrogen Metabolism: Nitrate assimilation, biological nitrogen fixation, Lipid Metabolism: Synthesis and breakdown of triglycerides, -oxidation, glyoxylate cycle, gluconeogenesis and its role in mobilization of lipids during seed germination,	12

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	Developmental roles of Phytohormones (auxins, gibberellins, cytokinins, ABA, ethylene); Photoperiodism; Phytochrome, photomorphogenesis, Seed Dormancy, Vernalization & Senescence	

08/BOT/MNR/301P: Practical for Plant Ecology and Physiology

Credits	Hours	Marks	Total Hr
2	4	10+40=50	60

Laboratory Exercise:

1. Study of ecosystem components using field observation (biotic and abiotic factors)
2. Determination of primary productivity (light and dark bottle method/simulation)
3. Analysis of food chain and ecological pyramid models
4. Measurement of transpiration using potometer
5. Determination of stomatal index (leaf peel method)
6. Estimation of chlorophyll content in leaves
7. Separation of photosynthetic pigments by paper chromatography
8. Demonstration of respiration rate using respirometer
9. Estimation of reducing sugars (respiratory substrate analysis)
10. Demonstration of fermentation (anaerobic respiration)
11. Bioassay of plant growth regulators (auxin effect)
12. Study of seed germination under different conditions
13. Demonstration of phototropism/geotropism
14. Identification of mineral deficiency symptoms in plants

Suggested reading

1. Taiz, L., Zeiger, E., Møller, I. M., & Murphy, A. (2022). Plant Physiology and Development (7th ed.). ISBN: 978-0197577240. Publisher: Oxford University Press / Sinauer Associates.
2. Larcher, W. (2021). Physiological Plant Ecology: Ecophysiology and Stress Physiology of Functional Groups (5th ed.). ISBN: 978-3030408391. Publisher: Springer.
3. Fitter, A. H., & Hay, R. K. M. (2021). Environmental Physiology of Plants (4th ed.). ISBN: 9780124020620. Publisher: Academic Press.
4. Lambers, H., Chapin III, F. S., & Pons, T. L. (2019). Plant Physiological Ecology (3rd ed.). ISBN: 978-3319915565. Publisher: Springer.
5. Gurevitch, J., Scheiner, S. M., & Fox, G. A. (2020). The Ecology of Plants (3rd ed.). ISBN: 978-1605352619. Publisher: Sinauer Associates.
6. Barbour, M. G., Burk, J. H., Pitts, W. D., Gilliam, M. L., & Schwartz, M. W. (2016). Terrestrial Plant Ecology (4th ed.). ISBN: 978-0321554234. Publisher: Pearson.
7. Smith, T. M., & Smith, R. L. (2012). Elements of Ecology (8th ed.). ISBN: 978-0321734912. Publisher: Pearson.
8. Marschner, H., & Marschner, P. (2023). Marschner's Mineral Nutrition of Higher Plants (4th ed.). ISBN: 9780323917625. Publisher: Academic Press / Elsevier.
9. Pessarakli, M. (Ed.). (2024). Handbook of Plant and Crop Physiology (4th ed.). ISBN: 9781032319513. Publisher: CRC Press / Taylor & Francis.
10. Schultz, J. C., Tumlinson, J. H., & Tumlinson, J. H. (2022). Plant Ecology (2nd ed.). ISBN: 9780521838353. Publisher: Cambridge University Press.
11. Billings, W. D., & Mooney, H. A. (2020). Physiology of Plants in Natural Environments. ISBN: 9780195116533. Publisher: Oxford University Press.
12. Nobel, P. S. (2023). Physicochemical and Environmental Plant Physiology (5th ed.). ISBN: 9780128214548. Publisher: Academic Press / Elsevier.
13. Hüner, N. P. A., & Hopkins, W. G. (2020). Introduction to Plant Physiology (5th ed.). ISBN: 978-1119603797. Publisher: John Wiley & Sons.

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Four Year Undergraduate Programme (Botany) Syllabus, Semester-VI	
Session 2028-2029	
Part-A Introduction	
Subject	**Botany**
Semester	**VI**
Name of the Course	Fundamental Biotechnology
Course Code	**08/BOT/MNR/351T**
Course Type:	MNR
Level of the course (As per Annexure-I)	300-399
High-Level Courses	
Course Learning Outcomes (CLO)	After completing the course: CLO1: understand the basics of *in vitro* cellular and developmental biology. CLO2: use various tools and techniques of plant biotechnology. CLO3: use *in vitro* means of plant propagation. CLO4: understand the basic concept of genetic engineering and their use. CLO5: use tools and techniques of biotechnology for the welfare of society.
Credits	4+2=6
Total Marks	20+80=100 Theory and 10+40=50 Practical; Total Marks=150
Part-B Contents of the Course	
Total lecture per week	4Theory+4Practical=8hr

Units	**Topics**	**No. of Lecture/Contact Hours**
I	Biotechnology: Basic concept (ancient and modern biotechnology), definitions and history of development. Major fields of biotechnology and applications. Cell theory and concept of totipotency and pluripotency.	12
II	History of plant tissue culture: Beginning of plant cell, tissue and organ culture. Concept of aseptic culture. Basic tools and techniques in plant biotechnology. Various types of culture medium.	12
III	Various means of micropropagation of plants: somatic embryogenesis, organogenesis and axillary shoot activation. Maintenance of cultures in growth chamber. Hardening of *in vitro* regenerated plantlets and field transfer.	12
IV	Various methods of protoplast isolations and culture. Somatic hybrids and cybrids. *In vitro* production of secondary metabolites/natural plant products.	12
V	*Agrobacterium tumefaciens*: natural genetic engineering; molecular biology and strategies for genetic modification of higher plants. Various physical and chemical methods of gene transfer in plants and its applications. Nanobiotechnology. IPR and ethical concern.	12

08/BOT/MNR/351P: Practical for Introduction to Biotechnology

Credits	**Hours**	**Marks**	**Total Hr**
2	**4**	**10+40=50**	**60**

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Laboratory Exercises:

1. Prepare MS Medium using suitable PGRs for activation of axillary shoot bud. Surface sterilized suitable explant and inoculate under aseptic condition.
2. Prepare MS Medium using suitable PGRs for induction of callus from haploid cells (anther). Surface sterilized suitable explant and inoculate under aseptic condition.
3. Prepare MS Medium using suitable PGRs for induction of callus from somatic cells. Surface sterilized suitable explant (young leaf, apical shoots, nodal shoot segment) and inoculate under aseptic condition.
4. Prepare MS Medium using suitable PGRs for induction of *in vitro* rooting and inoculate *in vitro* regenerated shoots under aseptic condition.
5. *Ex vitro* rooting.
6. Prepare synthetic seeds.
7. Design an experiment for acclimatization/hardening of *in vitro* regenerated plantlets.
8. Separation of secondary metabolites using thin layer chromatography (TLC).

Spots:

1. Contribution of botanist in plant biotechnology: Gottlieb Haberlandt, PR White, Ball, Miller and Skoog, Guha and Maheshwari.
2. Tools for aseptic culture: Laminar air flow bench, Autoclave.
3. Growth chamber, Hardening unit, Micropropagation
4. Organogenesis, Somatic embryogenesis, Synthetic seeds.
5. Bioreactor
6. *In vitro* production: Shikonin, Diosgenin.
7. Transgenic plants: *Bt* cotton, Golden rice

Recommended Books:

1. Chakravarty, A. K. (2013). *Introduction to Biotechnology*. Oxford University Press India.
2. Renneberg, R., & Demain, A. L. (2016). *Biotechnology for Beginners* (2nd ed.). Academic Press.
3. Godbey, W. T. (2014). *An Introduction to Biotechnology: The Science, Technology and Medical Applications*. Cambridge University Press.
4. Thieman, W. J., & Palladino, M. A. (2012). *Introduction to Biotechnology* (3rd ed.). Pearson.
5. Rajpal, T., & Gupta, R. (2025). *Biotechnology for All*. Wiley India.
6. Smith, J. (2011). *Introduction to Biotechnology: Tools, Techniques, and Applications*. McGraw-Hill.
7. Clark, D. P., & Pazdernik, N. J. (2015). *Biotechnology: Applying the Genetic Revolution* (2nd ed.). Academic Press.
8. Ignacimuthu, S. (2005). *Basic Biotechnology*. Cambridge University Press.
9. Bhojwani, S. S., & Dantu, P. K. (2013). *Plant Tissue Culture: An Introductory Text*. Springer.

Practical Books (5 Books)

1. Adhav, M., & Nagar, S. (2014). *Practical Book of Biotech. and Plant Tissue Culture*. S. Chand Publishing.
2. Hemanthakumari, B., et al. (2016). *Practical Manual of BSc Biotechnology*. DAV College Jalandhar.
3. Kumar, A. (2020). *Laboratory Manual of Biotechnology*. I.K. International.
4. Dubey, R. C. (2018). *A Practical Manual of Biotechnology*. Agrobios India.
5. Slater, A., et al. (2012). *Plant Biotechnology: The Genetic Manipulation of Plants - Lab Manual* (2nd ed.). Oxford University Press.

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Four Year Undergraduate Programme (Botany) Syllabus, Semester-VII		
Session 2029-2030		
Part-A Introduction		
Subject	**Botany**	
Semester	**VII**	
Name of the Course	Cytogenetics and Plant Breeding	
Course Code	**08/BOT/DSE/401T**	
Course Type:	DSE	
Level of the course (As per Annexure-I)	400-499	
Advance Courses		
Course Learning Outcomes (CLO)	After completing the course: After completion of the course the students will be able to: CLO1: understand basic tools and technique of plant breeding. CLO2: learn advanced concepts in plant breeding, including genetic variation, heritability, genotype-by environment interactions, and breeding strategies. CLO3: design and execute plant breeding experiments. CLO4: understand role of various national and international organization involved in improvement of plant and IPR.	
Credits	3+1=4	
Total Marks	15+60=75 Theory and 5+25=25 Practical; Total Marks=100	
Part-B Contents of the Course		
Total lecture per week	3Theory+2Practical=5hr	

Units	**Topics**	**No. of Lecture/Contact Hours**
I	Structure and function of chromosomes. Euchromatin and heterochromatin, unique and repetitive DNA, chromosome structure throughout the cell cycle, banded, lampbrush, polytene, B chromosomes. Molecular mechanism of crossing over, chromosomal evidence of crossing over, genetic factors which affect the frequency of crossing over, genetic control of meiosis.	9
II	Plant breeding: concept, nature and history. Objectives of plant breeding and major achievements in India. Genetics, evolution and breeding: Wheat, Rice, Brassica and Groundnut; Plant breeding work done in India on these crops, achievements and future prospects.	9
III	Origin and history of plant domestication, natural and artificial selections and evolution of crop plants. Centers of origin of crop plants. Changes in morphological, agronomic and genetic features accompanying domestication of plants. Genetic basis of inbreeding and heterosis, exploitation of hybrid vigor, Male sterility and its application on crop improvement.	9

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IV	Mutation – Classification, induction of mutation, mechanism, repair; role in cytogenetic analysis and evolution; Mutation breeding, use of polyploidy and distant hybridization in plant breeding. Mechanisms and genetic bases of resistance/tolerance to biotic and abiotic stresses in plants, breeding for resistance/tolerance.	9

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V	Green revolution in India: history and achievements. Molecular breeding; fundamental aspects and applications. Molecular marker assisted selection (MAS) and improvement of plants. International Convention for the Protection of New Varieties of Plants (UPOV) convention and convention on biodiversity; Protection of Intellectual Property Rights: PBR, TRIPS, PPVFR and ICBD.	9

08/BOT/DSE/404PA: Practical for Cytogenetics and Plant Breeding

Credits	Hours	Marks	Total Hr
1	2	5+20=25	30

Laboratory exercise

1. Floral biology in self and cross-pollinating crop species
2. Selfing and crossing techniques in major field crops.
3. Determination of extent of outcrossing
4. Male sterility – detection & maintenance;
5. Self-incompatibility and techniques of maintenance and overcoming sporophytic and gametophytic incompatibility.
6. Localization of centers of origin of crop plants in map.
7. Identification of centers of origin of crop plants mentioned in the map.
8. Screening for quality traits; resistance/tolerance to biotic & abiotic stresses
9. Demonstration of quality seed production through nucleus and breeders seed production techniques.

Suggested Reading

1. Acquaah G (2007). Principles of Plant Genetics and Breeding, Blackwell Publishing Ltd. USA.
2. Allard RW (1999). Principles of Plant Breeding (2nd Edition), John Wiley and Sons, ISBN 0471023094,9780471023098.
3. Allard, R.W. 1960. Principles of Plant Breeding. John Wiley & Sons, New York.
4. Fehr, W.R. 1987. Principles of Cultivar Development (2 Volumes). Mac Millan Publishing Co., New York. Hays,H.K., Immer, F.R. and Smith, D.C. 1955. Methods of Plant Breeding. McGraw Hill Book Company, Inc., NewYork.
5. Lewin B (2008). Genes IX, Jones and Barlett Publishers, ISBN-10: 0763740632. Poehlman, J.M. 1986, BreedingField Crops. AVI Publishing Company, Connecticut. Simmonds (1995). Evolution of Crop Plants (2nd Edition) Longman.
6. Dagla H. R. and Shekhawat N. S. Origin of Agriculture: Science Reporter (NISCAIR-CSIR), January, 2006.
7. Singh, B.D. 2000. Plant Breeding-Principles and Methods. Kalyani Publishers, New Delhi.
8. Singh B. D. and Shekhawat N. S. 2019.Plant Breeding in 21st Century. Scientific Publisher, Jodhpur, India.

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Four Year Undergraduate Programme (Botany) Syllabus, Semester-VII	
Session 2029-2030	
Part-A Introduction	
Subject	**Botany**
Semester	**VII**
Name of the Course	Principles of Plant Pathology
Course Code	**08/BOT/DSE/402T**
Course Type:	**DSE**
Level of the course (As per Annexure-I)	400-499
Advance Courses	
Course Learning Outcomes (CLO)	After completing the course: CLO1: Gain a thorough understanding of the nature and importance of plant diseases, including their causes, symptoms, and effects on plant growth and development. CLO2: Learn about interactions between plant hosts and pathogens, including plant defence mechanisms and pathogen evasion strategies. CLO3: Gain knowledge of current trends and advancements in plant pathology research, including molecular and genetic approaches. CLO4: Develop skills in diagnosing plant diseases using symptom observation, pathogen isolation, and modern detection methods. CLO5: Develop skills in designing and evaluating integrated plant disease management strategies for sustainable crop production.
Credits	3+1=4
Total Marks	15+60=75 Theory and 5+25=25 Practical; Total Marks=100
Part-B Contents of the Course	
Total lecture per week	3Theory+2Practical=5hr

Units	**Topics**	**No. of Lecture/Contact Hours**
I	Terminology of plant pathology, General symptoms of plant diseases, Components of plant disease, Disease diagnosis. Host parasite interaction (Genetics and Molecular basis) and Pathogenesis.	9
II	Role of enzymes and toxins in plant diseases, Effects of infection on the host, Plant defence against pathogens, Plant disease epidemiology and Plant disease forecasting.	9
III	Principles of plant protection, Management of plant diseases (Physical, Chemical and Biological management, biocides, microbial pesticide), Induced resistance in Plants, Breeding for disease resistance, transgenic plants for disease resistance.	9
IV	Principles and methods of seed health testing, Seed borne pathogenic microorganisms, important disease caused by seed borne pathogen. Morphology and anatomy of seed in relation of infection, Mechanism of seed infection and Factors affecting seed infection.	9
V	Seed deterioration, mycotoxins, detection of mycotoxins, management of mycotoxin contaminant seeds, principles of seed borne disease controls, seed treatments (physical, chemical and biological methods), Quarantine for seed, seed laws and Seed certification.	9

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Laboratory exercise

Credits	Hours	Marks	Total Hr
1	2	5+20=25	30

1. Studies of some local Bacterial, Fungal, Nematode, Phytoplasma and Viral diseases.
2. Field visit for demonstration of diseases on wild and crop plants.
3. Isolation of fungal and bacterial pathogens from leaves.
4. Isolation of fungal and bacterial pathogens from stem, fruits and other aerial plant parts.
5. Isolation of seed borne mycoflora by standard blotter method.
6. Isolation of Seed borne mycoflora using potato dextrose agar plate method.
7. Location of infection in seed through hand section and microtome section.
8. Detection of aflatoxin contamination in stored seed samples by UV fluorescence light.
9. General study of Pesticides and their application.
10. Symptomology of some diseased specimens: White rust, downy mildew, Powdery mildew, Black rust, loose smut, Ergot, Leaf spot, Red rot, Wilt, Bacterial canker, Bacterial blight, Angular leaf spot , Mosaic, Little leaf, Phyllody.

Suggested Reading

1. Agrios, G.N. 1997. Plant Pathology. Academic Press, London.
2. Albajes, R., Gullino, M.L., Van Lenteren, J.C. and Elad, Y. 2000. Integrated Pest and Disease management in Greenhouse Crops. Kiuwel Academic Publishers.
3. Mehrotra, R.S. 1993. Plant Pathology, Tata McGraw Hill.
4. Rangaswamy, G. and Mahadevan, A. 1999. Disease of crop plants in India. Prentice Hall of India, New Delhi.
5. Trivedi, P.C. 1998. Nematode disease in Plants CBS Publisher & Distributors, New Delhi. Roger, H. 2001. Mathew‟s Plant Virology, Academic Press,
6. NY. Strange, R.N. 2003. Plant resistance mechanism (SAR, ISR) –Introduction to plant Pathology, John Wiley & Sons, USA.
7. Singh, R.S. 1998. Plant disease. Oxford and IBH Publication Co. Pvt. Ltd.
8. Singh, R.S. 2005. Introduction to Principles of Plant Pathology. Oxford & IBH Publication Co. Pvt. Ltd.
9. Sharma, P.D. 2006. Plant Pathology. Narosa Publishing House, India
10. Pandey, B.P. 1997. Plant Pathology, Pathogen and Plant Disease. S. Chand and Company Ltd. Agarwal, V.K. and Sissclair, J.B. 1993. Principles of Seed Pathology. Vol. I & II CBS Publishers and Distributors, India
11. Neergaard, P. 1997. Seed pathology, Vol. I & II. The Macmillan Press.Ltd, London.
12. Suryanarayana, D. 1978. Seed pathology. Vikas Publishing House, Pvt, Ltd.

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Four Year Undergraduate Programme (Botany) Syllabus, Semester-VII	
Session 2029-2030	
Part-A Introduction	
Subject	**Botany**
Semester	**VII**
Name of the Course	Agriculture Microbiology
Course Code	**08/BOT/DSE/403T**
Course Type:	DSE
Level of the course (As per Annexure-I)	400-499
Advance Courses	
Course Learning Outcomes (CLO)	After completing the course: CLO1: Gain an understanding of the role of microorganisms in agricultural processes such as nutrient cycling, soil health, plant growth promotion, and disease control. CLO2: Learn about the diversity of microorganisms in different agricultural systems and their functional roles. CLO3: Gain an understanding of how to harness microorganisms for sustainable agriculture and food security. CLO4: Become proficient in laboratory techniques for isolation, characterization, and identification of agriculturally important microorganisms. CLO5: Develop skills in applying microbial resources for practical improvement of crop productivity and soil quality.
Credits	3+1=4
Total Marks	15+60=75 Theory and 5+25=25 Practical; Total Marks=100
Part-B Contents of the Course	
Total lecture per week	3Theory+2Practical=5hr

Units	**Topics**	**No. of Lecture/ Contact Hours**
I	Beneficial Microbes for Agriculture: Microbes (bacteria, fungi, and viruses) of agricultural importance, general classification, growth and reproduction. An overview about agriculturally important genera of Protozoa, Nematodes and Algae. Organic farming: concepts, principles and methodology.	9
II	Plant growth promoting microorganisms: mechanism of action and significance in increasing agricultural crop productivity, problems in application. Role of bacterial endophytes and fungal endophytes in improving crop production	9
III	Biofertilizers: Definition, types, methods of fertilizer application, importance to plant health. Rhizobium based biofertilizers, Fungal (Ecto- and Endomychorizae) based bio-fertilizers. Cyanobacterial biofertilizers. Azolla and Anabena symbiotic association. Various types of nitrogen fixing microorganisms	9
IV	Nanobiofertilizers: scope and impact in agriculture. Nano fertilizers definition and basic concept. A brief overview of synthesis (biological and chemical) and characterization of nanoparticles. Risk assessment of Nano fertilizers. Mode of actions and mechanisms of Bioinsecticides, Biopesticides and Biofungicides	9

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V	Plant microbiome engineering. Selection of microbiome for sustainable agro-ecosystems. Genomics of agriculturally important microbes: current status of the genomic resources available for various microbes (bacteria and fungi) of agricultural importance.	9

Laboratory exercise

Credits	Hours	Marks	Total Hr
1	**2**	**5+20=25**	**30**

1. General microbiological techniques for culture of microbes.
2. Isolation and purification of root/shoot endophytic bacteria
3. Culture of cyanobacteria.
4. Quantification of microorganisms by serial dilution methods
5. Molecular identification of microbes
6. Studying the efficacy of different biofertilizers on crop productivity
7. Analyzing genomes of microbes for PGP traits
8 Screening salt (NaCl) tolerant bacteria
9 Screening High temperature tolerant bacteria

Suggested Reading

1. Bajaj YPS Biotechnology in Agriculture and forestry, Vol. 22 Springer Verlas.
2. Biotechnology in Agriculture, Mac Millon India Ltd., 1992, Edn. M.S.Swaminath.
3. Purohit SS: Agricultural Biotechnology (2003) Agribion India.
4. Mehrote RS: Plant Pathology Tata Mc Graw Hill (1980).
5. Winnacker : From Genes to clones Panima Publishing Corporation (2003).
6. Singh BKP (2011) Biotechnological Applications in Environment and Agriculture. Swendea Publications.
7. Thakur (2008) Environmental Biotechnology: Basic Concepts and Applications. IK International publishers, New Delhi.
8. Wang LK, Ivanov V, Tay JH and Hung YT (2010) Environmental Biotechnology. Springer Publishing.

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Four Year Undergraduate Programme (Botany) Syllabus, Semester-VII	
Session 2029-2030	
Part-A Introduction	
Subject	**Botany**
Semester	**VII**
Name of the Course	Plant Microbes Interaction
Course Code	**08/BOT/DSE/404T**
Course Type:	DSE
Level of the course (As per Annexure-I)	400-499
Advance Courses	
Course Learning Outcomes (CLO)	After completing the course: **CLO1:** Gain an in-depth understanding of the importance of plant–microbe interactions for plant health, growth, development, and biological nitrogen fixation. **CLO2:** Learn the mechanisms of microbial colonization of plant tissues and factors influencing beneficial and pathogenic interactions. **CLO3:** Gain knowledge of the diversity and function of plant-associated microbial communities, including roles in plant growth promotion, stress tolerance, and disease suppression. **CLO4:** Learn how to design and conduct experiments on plant–microbe interactions, including inoculation techniques and plant phenotyping. **CLO5:** Develop skills in analyzing and interpreting data from experiments on plant–microbe interactions.
Credits	3+1=4
Total Marks	15+60=75 Theory and 5+25=25 Practical; Total Marks=100
Part-B Contents of the Course	
Total lecture per week	3Theory+2Practical=5hr

Units	**Topics**	**No. of Lecture/Contact Hours**
I	Biology of plant-microbe interactions: Rhizosphere, rhizodeposition. Concepts of competition, mutualism and parasitism. Evolution of parasitism and symbiosis. Plant immunity: Gene for gene concept, r-gene and avr gene, evolution of susceptibility and resistance. Bacterial quorum sensing, Bacterial secretary systems	9
II	Plant growth promoting rhizobacteria (PGPR), Mechanisms of PGPR: Phosphate solubilization, siderophore production, ACC-deaminase, Phytohormones production and PGPR as bio-control agent. Consortium of Agriculturally important microbes. Known examples of bacterial (*Herbaspirillum*, *Gluconacetobacter*, *Azorcus*, *Burkholderia*) and Fungal endophytes	9
III	Mycorrhizae and their types, Biology of AM Fungi and their application, Classification of AM Fungi (Mortan & Benny, 1990; Schüßler et al., 2001; Walker and Schüßler, 2010), Phosphorus mobilization and uptake mechanism of AM Fungi, Nitrogen assimilation and metabolism of AM Fungi. Biology of symbiotic fungus *Piriformospora indica* and its applications.	9

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IV	Legume-rhizobia symbiosis, Actinorhizal plants and *Frankia*; Plant and bacterial factors in establishing root nodule (RN) symbiosis. *Sym* genes; regulation of Nitrogenase. Host inducible regulation. Mechanism of auto-regulation.	9
V	Plant–microbiota interactions: composition of plant-associated microbial communities, Emerging trends in microbial application: plant–microbiota interactions in Next-Generation crop breeding programmes, selection of microbiome for sustainable agro-ecosystems, microbiome-mediated stress resistance in plants, Synthetic microbial communities (SynComs), Plant microbiome engineering, complexity and challenges of field application of plant-associated microbiota.	9

Laboratory Exercises

Credits	Hours	Marks	Total Hr
1	**2**	**5+20=25**	**30**

1. Preparation of culture media (TY, YEMA, LB)
2. Study of types of root nodules/morphology/anatomical preparation showing infection zone etc.
3. Isolation of bacteria from various sources (root nodules, roots and stems and phyllosphere).
4. Methods of culturing bacteria
5. Purification of bacterial isolates
6. Preservation of bacterial cultures (short term and long term)
7. Phenotypic characterization of bacterial isolates
   - (i) Intrinsic antibiotic resistance (IAR) pattern
   - (ii) NaCl tolerance
   - (iii) Acid or alkali production
   - (iv) High temperature tolerance
   - (v) Carbon utilization profile
8. Biochemical characterization of bacterial isolates
   - (i) Nitrate reductase activity
   - (ii) Citrate Utilization
   - (iii) Hydrolysis of starch
9. Demonstration of phosphate solubilization by bacterial isolates using PVK medium
10. Ammonia production by bacterial isolates.
11. Molecular characterization of bacterial isolates
    - (i) Assessing genetic diversity among the bacterial isolates on the basis of RAPD and ARDRA.
    - (ii) Amplification of protein-coding housekeeping genes in rhizobial strains.
    - (iii) Amplification of symbiotic genes in rhizobial strains.
    - (iv) Analyzing the gene sequences using NCBI-BLAST.
    - (v) Phylogenetic analysis using MEGA software.
12. Extraction and identification of Mycorrhizal spores from rhizosphere soil.
13. Staining of roots for assessment of Mycorrhizal colonization.
14. Mass multiplication of monospecific culture of AM fungi.
15. Microscopic preparation and study of fungus *Piriformospora indica* (If available)
16. Preparation of basic solid media, agar slant for cultivation of pathogenic microorganism.
17. Isolation of fungal and bacterial pathogen from stems fruits and other aerial plant parts.

Suggested Reading

1. *Bergey's Manual of Systematic Bacteriology*. Second Edition. Volume Two (The Proteobacteria).Springer.

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2. Boyd, R. F. 1984. *General Microbiology*. Times Mirror Publishers, New Delhi.
3. Chandra, S. and Kehri, H. K. 2006.*Biotechnology of VA Mycorrhizae*: *Indian Scenario*. New India Publishing Agency, New Delhi.
4. Dilworth, M. J., James, E. K., Sprent, J. I. and Newton, W. E. 2008.*Nitrogen-fixing Leguminous Symbioses*. Springer.
5. Pawlowski, K. and Newton, W. E. 2008.*Nitrogen-fixing Actinorhizal Symbioses*. Springer.
6. Pelczar, M. J., Chau, E. C. G. and Krieg, N. R. 1993.*Microbiology concepts and application*. McGraw Hill, New Delhi.
7. Power, C. B. and Daginawala, H. F. 1992.*General Microbiology*. Himalaya Pub. House, New Delhi.
8. Prescott, S. C. and Dunn, C. G. 1993.*Industrial Microbiology*. McGraw Hill Pub., New Delhi.
9. Salle, A. J. 2004. *Fundamental & Principles of Bacteriology*. Tata McGraw Hill Pub., New Delhi.
10. Smith, S. E. and Read, D. J. 1997. *Mycorrhizal Symbiosis*, Third Edition. Academic Press, London.
11. Somasegaran, P. and Hoben, H. J. 1994.*Handbook of Rhizobia* (*Methods in Legume-Rhizobium Technology*).Springer-Verlag.
12. Sprent, J. I. 2001. *Nodulation in legumes*.Kew Publishing.
13. Stéphane, D., Georges, S. D. and André, F. J. 2005.*In Vitro Culture of Mycorrhizas*.Springer.
14. Tiwari, M. and Sati, S. C. 2008.*The Mycorrhizae: Diversity Ecology & Applications*. Daya Publisher, New Delhi.
15. Vincent, J. M. 1970. *A manual for the practical study of the root nodule bacteria*. Blackwell Scientific Publications.
16. Lugtenberg B (ed) 2015. Principles of plant-microbe interactions. Springer International Publishing, Cham, Switzerland. https://doi.org/10.1007/978-3-319-08575-3
17. Sessitsch A, Pfaffenbichler N, Mitter B (2019) Microbiome Applications from Lab to Field: Facing Complexity. Trends in Plant Science. doi:10.1016/j.tplants.2018.12.004
18. Liu H, Brettell LE, Qiu Z, Singh BK (2020) Microbiome-Mediated Stress Resistance in Plants. Trends in Plant Science. 25(8), 733-743 https://doi.org/10.1016/j.tplants.2020.03.014
19. Qin Y, Druzhinina IS, Pan X, Yuan Z (2016). Microbially mediated plant salt tolerance and microbiome-based solutions for saline agriculture. Biotechnology Advances, 34(7), 1245-1259.
20. de Souza R, Armanhi J, Arruda P (2020) From Microbiome to Traits: Designing Synthetic Microbial Communities for Improved Crop Resiliency. Frontiers in plant science, 11, 1179. https://doi.org/10.3389/fpls.2020.01179
21. Compant S, Samad A, Faist H, & Sessitsch A (2019) A review on the plant microbiome: Ecology, functions, and emerging trends in microbial application. Journal of advanced research, 19, 29-37
22. Stanley CE, van der Heijden M G (2017) Microbiome-on-a-chip: new frontiers in plant–microbiota research. Trends in microbiology, 25(8), 610-613.
23. Gopal M & Gupta A (2016) Microbiome selection could spur next-generation plant breeding strategies. Frontiers in microbiology, 7, 1971. https://doi.org/10.3389/fmicb.2016.01971
24. Arif I, Batool M, Schenk PM (2020) Plant microbiome engineering: expected benefits for improved crop growth and resilience. Trends Biotechnol. 1–12. 10.1016/j.tibtech.2020.04.015
25. Toju H, Peay KG, Yamamichi M et al. (2018) Core microbiomes for sustainable agroecosystems. Nature Plants 4, 247–257. https://doi.org/10.1038/s41477-018-0139-4
26. Jones P, Garcia BJ, Furches A, Tuskan GA, Jacobson D (2019) Plant host-associated mechanisms for microbial selection. Front. Plant Sci. 10, 862. doi: 10.3389/fpls.2019.00862

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Four Year Undergraduate Programme (Botany) Syllabus, Semester-VII	
Session 2029-2030	
Part-A Introduction	
Subject	**Botany**
Semester	**VII**
Name of the Course	Microbial Ecology
Course Code	**08/BOT/DSE/405T**
Course Type:	DSE
Level of the course (As per Annexure-I)	400-499
Advance Courses	
Course Learning Outcomes (CLO)	After completing the course: CLO1: Explain key concepts and the diversity of microorganisms in ecological contexts. CLO2: Interpret microbial community structure, diversity, and mechanisms of genetic exchange. CLO3: Analyze the roles of microorganisms in ecosystem processes and nutrient cycles. CLO4: Assess environmental factors influencing microbial distribution, activity, and community dynamics. CLO5: Apply microbial ecological principles to study interactions, biogeochemical cycles, and environmental applications.
Credits	3+1=4
Total Marks	15+60=75 Theory and 5+20=25 Practical; Total Marks=100
Part-B Contents of the Course	
Total lecture per week	3Theory+2Practical=5hr

Units	Topics	No. of Lecture/Contact Hours
I	Historical development of microbial ecology; relationship with general ecology; characteristics of microbial life; microbial cell shape and evolution; metabolic diversity; growth and reproduction; species concept in microbiology; three domains of life; overview of microbial diversity (bacteria, archaea, eukaryotes); ecological significance of microbes	9
II	Microbial genome diversity; microbial community structure and stability; species diversity concepts; diversity indices; molecular diversity assessment; genetic exchange in microbes; horizontal gene transfer; microbial population structure; ecological and evolutionary significance of diversity.	9
III	Microorganisms in natural habitats (soil, aquatic); microbes in extreme environments; abiotic factors affecting growth; environmental regulation of microbial activity; nutrient limitation; survival strategies (starvation, dormancy); microbial metabolism in situ; heterotrophic potential; microbial productivity; decomposition processes.	9
IV	Types of microbial interactions (mutualism, commensalism, competition, parasitism, predation); population interactions; biofilms; quorum sensing; microbial community development; population dynamics; r- and K-strategies; microbial succession; community changes during organic matter degradation.	9

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V	Detection of microbial populations (phenotypic and molecular methods); non-culturable microorganisms; estimation of microbial abundance (direct and viable counts); biomass estimation; microbial associations with plants and animals; microbial roles in biogeochemical cycles (C, N, S, P); biodegradation; microbial activity in natural systems; principles of bioremediation and ecological impact assessment.	9

Laboratory exercises

Credits	Hours	Marks	Total Hr
1	**2**	**5+20=25**	**30**

1. Study of microbial communities in a natural environment using Winogradsky column.
2. Enrichment and isolation of microorganisms from environmental samples.
3. Isolation of microorganisms with specific capabilities/adaptations:
   a. Temperature-resistant microorganisms
   b. Anaerobic microorganisms
   c. Halophilic microorganisms
   d. Cellulolytic microorganisms
   e. Chitin-decomposing microorganisms
   f. Methane-utilizing bacteria
   g. Phosphatase-active microorganisms
   h. Photosynthetic bacteria
   i. Nitrifying bacteria
   j. Cyanobacteria (blue-green algae)
4. Study of microbial growth and nutrient requirements.
5. Selection and screening of metabolite-producing microorganisms.
6. Study of enzyme activities in microorganisms:
   a. Dehydrogenase; b. Urease; c. β-glucosidase
   d. Acid and alkaline phosphatase
7. Techniques for isolation, enumeration, and observation of microorganisms:
   a. Serial dilution and dilution series; b. Surface plate method; c. Streak plate method
   d. Agar stab method; e. Overlay method; f. Filter disc method
   g. Hanging drop method; h. Micrometry; i. Staining techniques
8. Estimation of microbial diversity:
   a. Preparation of phenogram
   b. Measurement of diversity indices
   c. Measurement of genetic diversity indices

Suggested Reading

1. Aronson, S. 1970. *Experimental Microbial Ecology*. Academic Press.
2. Atlas, R. M. and Bartha, R. 1998. *Microbial Ecology: Fundamentals and Applications*. Benjamin/Cummings Science Publishing.
3. Bernhard, S. 2000. *Advances in Microbial Ecology*. Springer.
4. Burlage, R. S. 1998. *Techniques in Microbial Ecology*. Oxford University Press.
5. Cheeke, T. E., Coleman, D. C. and Wall, D. H. 2012. *Microbial Ecology in Sustainable Agroecosystems*. CRC Press.
6. Coleman, D. C., Crossley, D. A. and Paul, E. A. 2004. *Fundamentals of Soil Ecology*. Academic Press.
7. Kirchman, D. L. 2012. *Processes in Microbial Ecology*. Oxford University Press.
8. Loutit, M. W. and Miles, J. A. R. 2011. *Microbial Ecology*. Springer, London.
9. McArthur, J. V. 2006. *Microbial Ecology: An Evolutionary Approach*. Academic Press.
10. Singer, S. 2001. *Experiments in Applied Microbiology*. Academic Press.

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Four Year Undergraduate Programme (Botany) Syllabus, Semester-VII	
Session 2029-2030	
Part-A Introduction	
Subject	**Botany**
Semester	**VII**
Name of the Course	Industrial Microbiology
Course Code	**08/BOT/DSE/406T**
Course Type:	DSE
Level of the course (As per Annexure-I)	400-499
Advance Courses	
Course Learning Outcomes (CLO)	After completing the course: CLO1: Gain advanced knowledge of the fundamental principles and concepts of industrial microbiology, fermentation, and bioreactor design. CLO2: Understand the role of microbial enzymes and fermentation processes in the food, dairy, and beverage industries. CLO3: Gain advanced knowledge of the diversity of industrial microorganisms and their applications in bioremediation, biofuels, and bioplastics. CLO4: Learn to analyze and design industrial fermentation systems for optimized microbial production. CLO5: Develop skills in evaluating the economic and environmental impacts of microbial processes in industrial applications.
Credits	3+1=4
Total Marks	15+60=75 Theory and 5+20=25 Practical; Total Marks=100
Part-B Contents of the Course	
Total lecture per week	3Theory+2Practical=5hr

Units	**Topics**	**No. of Lecture/Contact Hours**
I	Fundamentals of Industrial Microbiology: Definition, scope and historical development of Industrial microbiology**,** Fermentors (Bioreactor): Principle, types (Submerged, Solid-state), Batch, Continuous, and Fed-batch fermentation process. Strain Development, Stock Cultures, Fermentation media. Biological waste treatment.	9
II	Microbial production of Primary and Secondary, Commercial production of Penicillin, Streptomycin, and their semi-synthetic derivatives; Biotransformation, High-Value Recombinants: Human proteins (Insulin, Somatostatin), Vaccines.	9
III	Microbiology and production of Malt beverages (Beer), Distilled beverages (Whiskey/Brandy), Organic Acids, Amino Acids & Vitamins	9
IV	Enzyme Technology: Production and industrial applications of Cellulases, Xylanases, Pectinases, Amylases, Lipases, and Proteases. Dairy Microbiology: Milk fermentation; production of fermented (Yogurt, Cheese) and non-fermented dairy products.	9
V	Green Products: Bioplastics, and Biosurfactants. Agriculture: Biofertilizers; Bio-insecticides (PIP - Plant Incorporated Protectants) and Biopesticides.	9

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Laboratory exercise

Credits	Hours	Marks	Total Hr
1	2	5+20=25	30

1. Preparation of culture media.
2. Culturing of microorganisms and cultural characteristics of bacteria.
3. Study of some important industrially important genera of fungi.
4. Techniques for microbial stock culture preservation (Glycerol stocks and Lyophilization demonstration)
5. Primary screening for antibiotic producers' microorganism.
6. Primary screening for amylase producers (Starch Hydrolysis)
7. Methylene Blue Reduction Test (MBRT) to check the microbial quality of raw milk.
8. Preparation of fermented dairy products at a laboratory scale
9. Metabolism of microorganisms–carbohydrate fermentation, urea and gelatin.
10. Effect of various factors on the growth of microorganisms (pH, Temp,UV light)
11. Cultivation of Nitrogen fixing Biofertilizers: Rhizobium, Azospirillum, Azatobacter.
12. Oligodynamic action of heavy metals.
13. Antibiotic sensitivity test by agar disc diffusion and
14. Lab-scale production of Ethanol from fruit juice/molasses using Saccharomyces cerevisiae
15. Isolation &identification of Mycorrhizal fungi from Rhizosphere soil.
16. Production of penicillin
17. Production of citric acid.
18. Isolation and characterization of bacteria from hydrocarbon contaminated soils.

Suggested Reading

1. Casida,L.E. Industrial Microbiology. John Wiley and sons. Chum. Microbiology. John Wiley&Sons.
2. Corum ,C.J. Development of Industrial Microbiology. American Institute of Bio. Science.
3. Dube .C. and Maheshwari D.K., A Text Book of Microbiology, S. Chand and co. Ltd
4. Dube R. C., and Maheshwari D.K. , Practical Microbiology , S. Chand and co. Ltd Kaushik, P. Microbiology. Emkay Pub., New Delhi.
5. Pelczer, M.J., Chau, E.C.G. and Krieg, N.R. Microbiology Concepts and application.McGraHill. Power,C. B. and
6. Daginawala, H.F. General Microbiology. Himalaya Pub. House.
7. Prescott,S.C.and Dunn,C.G. Industrial Microbiology. McGraw Hill Pub.
8. Robert F. Boyd. General Microbiology. Times Mirror Publishers.
9. Salle, A. J. Fundamental & Principles of Bacteriology. Tata McGRaw Hill.
10. Sivakumar P.K., Joe M .M, Sukesh K , An Introduction to Industrial Microbioloy, Pub.: S. Chand and co. Ltd
11. Spencer, J.E.T. and Spencer, D.M. Yeast Technology. Springer-Verlag.

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Four Year Undergraduate Programme (Botany) Syllabus, Semester-VII	
Session 2029-2030	
Part-A Introduction	
Subject	**Botany**
Semester	**VII**
Name of the Course	Stress Physiology
Course Code	**08/BOT/DSE/411T**
Course Type:	DSE
Level of the course (As per Annexure-I)	400-499
Advance Courses	
Course Learning Outcomes (CLO)	After completing the course: CLO1: Understand types of abiotic stresses and their early adaptive and physiological effects on plants. CLO2: Explain molecular and biochemical mechanisms of stress tolerance, including osmotic adjustment, stress-responsive genes, and protective proteins. CLO3: Analyze ROS production and antioxidant systems (enzymatic and non-enzymatic) under abiotic and biotic stresses. CLO4: Learn the role of plant growth regulators (ABA, ethylene, SA, JA) in stress signaling and adaptation. CLO5: Apply biotechnological strategies for improving crop stress tolerance and designing stress-management approaches.
Credits	3+1=4
Total Marks	15+60=75 Theory and 5+20=25 Practical; Total Marks=100
Part-B Contents of the Course	
Total lecture per week	3Theory+2Practical=5hr

Units	**Topics**	**No. of Lecture/Contact Hours**
I	Types of abiotic stresses: drought, salinity, temperature extremes, high light, fluoride, CO_2; Early adaptive responses and structural/physiological effects of stress; Photoinhibition of photosystems under stress; Photoprotection and repair mechanisms of Photosystem II; Stomatal regulation under stress	9
II	Ionic and osmotic sensing: SOS pathways; Molecular basis of water deficit, salt, and temperature tolerance; Biochemical mechanisms: osmotic adjustment, compatible solutes; Use of transgenic approaches to improve crop stress tolerance	9
III	Stress-responsive genes and regulatory pathways; Structure and function of HSPs, ANPs, PR proteins, LEA proteins, aquaporins, osmotin, systemins, defensins, ubiquitins; Expression of stress signaling pathway genes under drought, salinity, and temperature; Biotic stress tolerance: molecular mechanisms and transgenic approaches for pathogen resistance	9
IV	ROS production under abiotic and biotic stresses; Enzymatic antioxidants: SOD, CAT, APX, GPX; Non-enzymatic antioxidants: ascorbate, glutathione, phenolics; Haliwal-Asada pathway and ROS scavenging mechanisms	9

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V	Role of plant growth regulators (PGRs) in stress mitigation; ABA, Ethylene, Salicylic acid, and Jasmonic acid signaling in abiotic and biotic stress responses; Integration of hormonal and molecular pathways for stress adaptation; Strategies for crop improvement and stress management using biotechnology	9

Laboratory exercise

Credits	Hours	Marks	Total Hr
1	2	5+20=25	30

1. Find out the ascorbic content in temperature (low and high) and salt stressed samples.
2. Effect of stress on the activity of the following scavenging enzymes: Superoxide dismutase, Catalase and Peroxidase
3. Ascorbate peroxidase
4. Estimate anthocyanin content in stressed samples.
5. Effect of stress on membrane damage in relation to lipid peroxidation.
6. Effect of stress on membrane damage in relation to the membrane stability index.
7. Effect of water stress and Hyperthermia on the activity of nitrate reductase.
8. Estimate the free amino acid content in the given sample.
9. Estimate proline content in the given water-stressed samples.
10. Estimate glycine betaine content in salt-stressed samples.
11. Estimate total phenol content in salt-stressed samples.
12. Find out the soluble sugars in temperature (low and high) and salt-stressed samples.
13. Find out the concentration of polyamines in the given stressed samples.
14. Visualization of stress proteins by SDS-gel electrophoresis.
15. Study of antioxidant enzymes.

Suggested Reading

1. Ahmad, P ., Azooz, M.M.and Prasad M.N.V. 2013. Salt Stress in Plants: Signalling, Omics and Adaptations (eds). Springer
2. Aroca, R. 2012. Plant Responses to Drought Stress From Morphological to Molecular Features. (ed) Springer- Verlag Berlin Heidelberg.
3. Buchanan, B. B., Gruissem, W. and Jones, R. L. 2000. Biochemistry and molecular biology of plants. American Society of Plant Physiologists, Maryland, USA.
4. Cherry, J. H. 1994. Biochemical and cellular mechanisms of stress tolerance in plants (ed.). Springer-Verlag, Berlin.
5. Hir, T. H. 2009. Plant Stress Biology: From Genomics to Systems Biology (ed), Wiley-VCH Verlag Weinheim, Germany
6. Jenks, M.A. and. Wood A.J. 2009.Genes for Plant Abiotic Stress Tolerance. John Wiley & Sons.
7. Khan, M .N. and Mobin M. 2014. Nitric Oxide in Plants: Metabolism and Role in Stress Physiology (eds)Springer
8. Levitt, J. 1980. Responses of plants to environmental stress. Vol. 1. Chilling and temperature stress. Academic Press, New York, USA.
9. Pandey, G.K. 2015. Elucidation of Abiotic Stress Signaling in Plants: A Functional Genomic Perspective. Springer
10. Rout, G. R. and Das, A. B. 2013. Molecular Stress Physiology of Plants (eds.) Springer.
11. Samuelson, J.C. 2013. Enzyme Engineering: Methods and Protocols (ed) .Springer ,New York Sarwat, M., Ahmad, A. and Abdin, M.Z . 2013.Stress Signaling in Plants: Genomics and Proteomics Perspective. Vol. 1 . Springer
12. Tuteja, N. and Gill, S.S. 2014. Climate Change and Plant Abiotic Stress Tolerance (eds.). Wiley-VCHVerlag Weinheim, Germany.
13. Yoshioka, K.and Shinozaki, K. 2009. Signal Crosstalk in Plant Stress Responses (eds). Willey-Blackwell.

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Four Year Undergraduate Programme (Botany) Syllabus, Semester-VII	
Session 2029-2030	
Part-A Introduction	
Subject	**Botany**
Semester	**VII**
Name of the Course	Plant Molecular Biology & Biotechnology
Course Code	**08/BOT/DSE/412T**
Course Type:	DSE
Level of the course (As per Annexure-I)	400-499
Advance Courses	
Course Learning Outcomes (CLO)	**After completing the course:** CLO1: gain knowledge of the fundamental principles of plant molecular biology. CLO2: understand somatic cell genetics and molecular marker based genetic analysis. CLO3: gain knowledge of plant transcriptomics, proteomics and metabolomics. CLO4: develop skills in molecular biology. CLO5: develop skills in plant biotechnology.
Credits	3+1=4
Total Marks	15+60=75 Theory and 5+20=25 Practical; Total Marks=100
Part-B Contents of the Course	
Total lecture per week	3Theory+2Practical=5hr

Units	**Topics**	**No. of Lecture/ Contact Hours**
I	Techniques in Molecular Biology: Electrophoresis, blottings, thermocyclers. Separation of Proteins: extraction and purification of proteins amenable to 1-D and 2-D electrophoresis. Purification of proteins by various types of chromatography.	9
II	Gene expression and function analysis: Separation of chromosome and localization of gene on chromosome. Various means of transcript analysis: localization of introns and separation of exons; identification of start and end points of transcript. Localization and identification of protein binding sites and control sequences of gene expression. Identification of translation products of cloned gene: HRT, HART and protein-protein interaction.	9
III	Genome analyses and gene sequencing: shotgun cloning and clone contig approaches. DNA markers and genetic maps: multilocus and locus specific DNA markers, ESTs, ORFs and its applications. Molecular marker based genetic analysis of plants of arid environment.	9
IV	Transcriptome analyses: microarray and DNA chips; basic concept and applications. Proteome analyses: 2-D electrophoresis and MALDI-TOF. Site directed mutagenesis: technique and applications.Transcript and proteome analysis of halophytes and xerophytes: prospects and limitations. Productions of recombinant proteins and pharmaceuticals.	9
V	Somatic cell genetics of plants of arid regions, molecular biology of somatic embryogenesis and organogenesis. Genetic fidelity analysis of *in vitro*	9

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	regenerated plants by DNA markers. Plant genetic engineering: gene addition (insect and herbicide resistance) and gene subtraction (antisense) technology and its applications. Bioinformatics and computational biology: fundamental and applied aspects.	

Laboratory exercises

Credits	Hours	Marks	Total Hr
1	2	5+20=25	30

1. Extract Genomic DNA, Protein and RNA from plants of arid environment.
2. Estimate DNA, RNA and Protein from plants.
3. Analyze DNA, RNA and Protein/enzyme by electrophoresis.
3. Study of molecular analysis of somatic embryogenesis and organogenesis
4. Genetic diversity analysis of plants of arid environment
5. Genetic fidelity analysis of in vitro regenerated plants
6. Gene analysis by RT-PCR
7. Agrobacterium-mediated plant genetic transformation of tomato.
8. Prepare phylogenetic tree through NTYSIS software, and analyze genetic diversity.
9. Database searching and sequence retrieval of nucleic acids and proteins.

Suggested Reading

1. Bhojwani, S.S. 1990. Plant Tissue Culture: Applications and Limitations. Elsevier Science Publishers, NewYork, USA.
2. Bhojwani, S.S. and Razdan, M.K. 1996. Plant Tissue Culture: Theory and Practice (a revised edition). Elsevier Science Publishers, New York, USA.
3. Brown, T.A. 1999. Genomes. John Wiley & Sons (Asia) Pvt. Ltd., Singapore. Brown,T. A. Gene Cloning and Data Analysis an Introduction, Blackwell Publishing Gustafson, J.P. 2000. Genomes. Kluwer Academic Plenum Publishers, New York, USA.
4. Hartl, D. L. and Jones, E. W. 1988. Genetics: Principles and Analysis (4th edition). Jones & Bartlett Publishers, Massachusetts, USA.
5. Henry, R.J. 1997. Practical Applications of Plant Molecular Biology. Chapman & Hall, London, UK. Jolles, O. and Jornvall, H. (eds) 2000. Proteomics in Functional Genomics. Birkhauser Verlag, Basel, Switzerland.
6. Kayser,O. and Quax,W. (eds) 2007.Medicinal Plant Biotechnology From Basic Research to Industrial Applications. Wiley-VCH Verlag.
7. Old, R.W. and Primrose, S.B. 1989. Principles of Gene Manipulation. Blackwell Scientific Publications, Oxford, UK.
8. Primrose, S.B. 1995. Principles of Genome Analysis and Genomics. Blackwell Science Ltd., Oxford, UK.
9. Raghavan, V. 1986. Embryogenesis in Angiosperms: A Developmental and Experimental Study.
10. CambridgeUniversity Press, New York, USA.
11. Raghavan, V. 1997. Molecular Biology of Flowering Plants. Cambridge University Press, New York, USA.
12. Russel, P. J. 1998. Genetics (5th edition). The Benjamin/Cummings Publishing Company Inc.,
13. USA. Snustad, D. P. and Simmnns, M. J. 2000. Principles of Genetics (2nd edition). John Wiley & Sons Inc., USA.
14. Vasil, I.K. and Thorpe, T.A. 1994. Plant Cell and Tissue Culture. Kluwer Academic Publishers, The Netherlands.

Suggested Readings (Laboratory Exercises)

1. Butenko, R.G. 2000. Plant Cell Culture. University Press of Pacific.
2. Collin, H.A. and Edwards, S. 1998. Plant Cell Culture. Bios Scientific Publishers, Oxford, UK. Dixon, R.A. (ed.) 1987. Plant Cell Culture: A Practical Approach. IRL Press, Oxford.
3. Gelvin, S.B. and Schilperoort, R.A. (eds) 1994. Plant Molecular Biology Manual, 2nd edition, Kluwer Academic Publishers, Dordrecht, The Netherlands.
4. Glick, B.R. and Thompson, J.E. 1993. Methods in Plant Molecular Biology and Biotechnology. CRC Press,Boca Raton, Florida.
5. Hall, R.D. (ed) 1999. Plant Cell Culture Protocols. Humana Press, Inc., New Jersey, USA.
6. Sambrook, J, Fritsch, E.F. and Maniatis, T. (1989) Molecular Cloning: a laboratory manual. 2nd ed. N.Y. Cold Spring Harbor Laboratory, Cold Spring Harbor Laboratory press.
7. Shaw, C.H. (ed) 1988. Plant Molecular Biology: A Practical Approach. IRL Press, Oxford.
8. Smith, R.H. 2000. Plant Tissue Culture: Techniques and Experiments. Academic Press, New York.

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Four Year Undergraduate Programme (Botany) Syllabus, Semester-VII	
Session 2029-2030	
Part-A Introduction	
Subject	**Botany**
Semester	**VII**
Name of the Course	Plant Systematics
Course Code	**08/BOT/DSE/413T**
Course Type:	DSE
Level of the course (As per Annexure-I)	400-499
Advance Courses	
Course Learning Outcomes (CLO)	After completing the course: CLO1: Explain the conceptual basis of plant classification and the concept of family, genus and species and the taxonomic diversity within species. CLO2: Develop working skills in modern techniques in plant systematics CLO3: Choose appropriate tools of modern systematics for plant identification CLO4: Determine evolutionary relationship between a group of species using molecular taxonomic tools and techniques CLO5: Construct phylogenetic trees based on molecular systematic data
Credits	3+1=4
Total Marks	15+60=75 Theory and 5+20=25 Practical; Total Marks=100
Part-B Contents of the Course	
Total lecture per week	3Theory+2Practical=5hr

Units	**Topics**	**No. of Lecture/Contact Hours**
I	Fundamentals and History of Plant Systematics: Components: taxonomy, nomenclature, classification, phylogeny; Objectives and societal relevance; Taxonomic history: artificial, natural, phylogenetic systems; Phenetics vs cladistics; Taxonomy services and conservation	9
II	Identification, Nomenclature and Taxonomic Resources: Plant identification and taxonomic keys; Botanical nomenclature (ICN principles); Author citation, priority, typification; Naming new species, legitimacy, synonyms; Field survey and plant collection; Herbarium techniques and documentation; Floras, monographs, journals, digital taxonomy; Role of botanical gardens and Botanical Survey of India	9
III	Evolutionary Trends: Origin and evolution of angiosperms; Evolution of xylem, flower, stamen, pollen, and carpel; Floral Systematics: Morphological evolutionary innovations in flowers; Variation in floral forms; Pollination-related floral adaptations; Floral developmental diversity in angiosperms; Role of floral developmental genetics.	9
IV	Systematics of Basal Angiosperms and Monocots: General characteristics and evolutionary trends; Basal Angiosperms: ANA grade: Amborellales,	9

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	Nymphaeales, Austrobaileyales; Magnoliids: Magnoliales, Laurales, Canellales, Piperales; Chloranthales; Monocots: Basal monocots: Acorales, Alismatales; Petaloid monocots: Petrosaviales, Dioscoreales, Pandanales, Liliales, Asparagales; Commelinids: Commelinales, Zingiberales, Poales	
V	Systematics of Eudicots: General characteristics and evolutionary trends in eudicots; Basal Eudicots: Ranunculales, Proteales; Core Eudicots: Caryophyllids: Gunnerales, Saxifragales, Caryophyllales; Rosids Superclade: Fabids: Zygophyllales, Malpighiales, Fabales, Cucurbitales; Malvids: Brassicales, Malvales, Sapindales; Asterids Superclade: Basal: Cornales, Ericales; Lamiids: Boraginales, Gentianales, Lamiales, Solanales; Campanulids: Aquifoliales, Apiales, Asterales	9

Laboratory/field exercises

Credits	Hours	Marks	Total Hr
1	2	5+20=25	30

1. Live plants/ Herbarium specimens of the following families will be provided in the class for descriptionand identification (classification based on APG III, 2009):
2. Basal Angiosperm and Magnoliids: Nymphaeaceae, Magnoliaceae
3. Basal monocots: Araceae, Alismataceae
4. Petaloid monocots: Liliaceae, Alliaceae, Asperagaceae, Amaryllidaceae, Iridaceae, Orchidaceae
5. Commelinids monocots: Commelinaceae, Zingiberaceae, Cyperaceae, Poaceae
2. Live plants/ Herbarium specimens of the following families will be provided in the class for description and identification (classification based on APG III, 2009):
    a) Basal Eudicots:-Ranunculaceae, Nelumbonaceae
    b) Caryophyllids: Caryophyllaceae, Amarathaceae
    c) Rosids: Zygophyllaceae, Euphorbiaceae, Rosaceae, Fabaceae, Cucurbitaceae, Capparaceae, Malvaceae
    d) Asterids: Boraginaceae, Acanthaceae, Orobanchaceae, Solanaceae, Lamiaceae, Apiaceae, Asteraceae
6. Writing exercise
7. Nomenclature exercise
8. Classification exercise
9. Systematic evidences studies of pollen grain or metabolite or cytology of selected above families of genus
10. Preparation of Herbarium and excursion studies of desert region
11. Make a phenetic/cladistic cladogram through software

Suggested Reading

1. Angiosperm Phylogeny Group 2003. An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants: APG II. Botanical Journal of the Linnaean Society 141: 399-436.
2. Cronquist, A. 1981. An integrated system of classification of flowering plants. Columbia University Press, New York.
3. Friis E.M., Crane P.R. Pedersen K.R. 2011, Early Flowers and angiosperm evolution. Cambridge University Press
4. Gurcharan Singh, 2010.Plant Systematics: An Integrative Approach. Science Publishers, Enfield, NH, USA Judd, W.S., C.S. Campbell, E.A. Kellogg, P.F. Stevens and M.J. Donoghue 2002. Plant Systematics: A phylogenetic Approach. Sinauer Associates, Inc.,

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Massachusetts.
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6. Simpson, M.G. 2006. Plant Systematics. Elsevier, Amsterdam.
7. Simpson, M.G. 2010. Plant Systematics, Second Edition. Elsevier, Amsterdam
8. Soltis D. et al., 2005, Phylogeny and Evolution of the Angiosperm, Sinauer Associates, Inc, Publishers,Sunderland, Massachusetts.
9. Soltis D. et al., 2018, Phylogeny and Evolution of the Angiosperm, Revised & updated edition, Universityof Chicago Press, Chicago & London
10. Takthtajan A. 2009. Flowering Plant, Second Edition. Springer
11. Wilson K.L., Morrison D.A. 2000, Monocots systematics and Evolution. CSIRO Publishing.
12. Winston J.E. 1999.Describing Species: Practical Taxonomic Procedure for Biologiest. Columbia UniversityPress.

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Four Year Undergraduate Programme (Botany) Syllabus, Semester-VII		
Session 2029-2030		
Part-A Introduction		
Subject	**Botany**	
Semester	**VII**	
Name of the Course	Plant resources utilization and Conservation	
Course Code	**08/BOT/DSE/414T**	
Course Type:	DSE	
Level of the course (As per Annexure-I)	400-499	
Advance Courses		
Course Learning Outcomes (CLO)	After completing the course: CLO1: Identify and manage endangered arid plants, habitat restoration, and conservation policies for genetic diversity. CLO2: Describe uses of arid plants for food, fiber, oil, timber, spices, and medicines. CLO3: Apply geospatial methods in plant research: design, analyze data, interpret statistics. CLO4: Explore emerging trends in plant resource utilization and conservation. CLO5: Integrate geospatial tools with arid plant conservation strategies.	
Credits	3+1=4	
Total Marks	15+60=75 Theory and 5+20=25 Practical; Total Marks=100	
Part-B Contents of the Course		
Total lecture per week	3Theory+2Practical=5hr	

Units	**Topics**	**No. of Lecture/ Contact Hours**
I	Agrobiodiversity: Agrobiodiversity hotspots in India, Endemic and threatened plant species of agrobiodiversity importance (in the different agrobiodiversity regions in India) Vavilov's Centre of Origin of crop plants. Wild relatives of cultivated plants: Crop Wild Relatives (CWR) indigenous to India (categories), importance of CWR as Plant Genetic Resource (PGR) and as socio economic resource, threats and conservation measures of CWR. Green revolution and new challenges of food security. Sustainable agriculture.	9
II	Origin, botany, cultivation, processing, chemical constituents and uses of Food: Wheat, Maize, Bajra; Fiber: Flax, Coir, Sun hemp, Semal; Oil plants: Sesame, Ground nut, Sunflower, Soyabean, castor oil; Timber: Teak, Sal, Rohida	9
III	Spices and Condiments: Chilli, Coriander, Ginger, Turmeric, Cloves, Fennel, Cumin, Methi; Medicinal Plants: Ashwagandha, Ephedra, Ocimum, Amla, Aloe; Sugar:-Manufacture of cane sugar, Ethanol; Gum and Resins; Forest Products of India	9
IV	Principles of Conservation biology: Definition and concept of conservation biology; Conservation strategies: IUCN threat categories, Red Data Book, RET plants of India, in-situ conservation (Biosphere reserves and National	9

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	Parks) and ex-situ conservation (Botanical gardens, seed bank and germplasm bank) and ecological restoration. Threats to biodiversity: Habitat degradation and loss, natural calamities, species invasions, overharvesting/overexploitation, habitat fragmentation and metapopulation dynamics.	
V	Application of Geospatial Technologies in Biodiversity Studies General introduction; Geospatial Technologies: Remote sensing (RS) and Geographical Information System (GIS); Application of RS and GIS in biodiversity and conservation: Forest management, management of Grasslands, agricultural biodiversity, habitat mapping and monitoring, monitoring of invasive species, Biodiversity assessment – Landscape to species.	9

Credits	Hours	Marks	Total Hr
1	2	5+20=25	30

A. Field Survey

1. Firewood & Timber Plants – List 10 local species with scientific names, families, and properties.
2. Urban Tree Assessment – Map trees, record size, canopy, flowering/fruiting, and health.
3. Conservation Status Survey – Identify threatened/endemic plants, note habitat and threats.

B. Laboratory Exercises

1. Locate centers of origin of agriculture on a map.
2. Quantify starch in food and forage crops.
3. Micro-chemical tests for fats & oils.
4. Study morpho-anatomical features of plant fibers.
5. Determine acid, iodine, and saponification values in vegetable oils.
6. Micro-chemical tests for gums, tannins, and dyes.
7. Test adulteration in honey, saffron, spices, and oils.
8. Identify food crops: wheat, maize, potato, chickpea, sugarcane, sweet potato.
9. Identify forage/fodder crops: sorghum, bajra, gram, guar bean.
10. Identify fiber crops: cotton, jute, coir, silk cotton.
11. Identify medicinal & aromatic plants: *Papaver, Catharanthus, Adhatoda, Allium, Rauvolfia, Withania, Phyllanthus, Aloe, Mentha, Rosa, Jasminum, Cymbopogon.*

C. Conservation Exercises

1. Map protected areas in India (biosphere reserves, parks, wetlands, mangroves).
2. Demonstrate in vitro germplasm conservation.
3. Produce synthetic seeds for endangered plants.
4. Study plant diversity in seed banks or botanical gardens.

Suggested Reading

1. Anonymous 1997. National Gene Bank: Indian Heritage on Plant Genetic Resources (Booklet). National Bureau of Plant Genetic Resources, New Delhi.
2. Arora, R.K. and Nayar, E.R. 1984. Wild Relatives of Crop Plants in India. NBPGR Science Monograph No.7.
3. Baker, H.G. 1978. Plants and Civilization (3rd ed.). C.A. Wadsworth, Belmont.
4. Bole, P.V. and Vaghani, Y. 1986. Field Guide to Common Indian Trees. Oxford University Press, Mumbai.Chandel, K.P.S., Shukla, G. and Sharma, N. 1996. Biodiversity of Medicinal and Aromatic Plants in India: Conservation and Utilization. National Bureau of Plant Genetic Resources, New Delhi.
5. Chrispeels, M.J. and Sadava, D. 1977. Plants, Food and People. W.H. Freeman and Co., San

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Francisco. Conway, G. 1999. The Doubly Green Revolution: Food for All in the 21st Century, Penguin Books.
6. Conway, G. and Barbier, E. 1990. After the Green Revolution, Earthscan Press, London.
7. Conway, G. and Barbier, E. 1994. Plant, Genes and Agriculture, Jones and Bartlett Publishers, Boston. Council of Scientific& Industrial Research (1948-2005). The Wealth of India. A Dictionary of Indian Raw Materials and Industrial Products, New Delhi. Raw Materials I-XII, Revised Vol. I-III (1985-1992) Supplement (2000).
8. Cristi, B.R. (ed.) 1999. Handbook of Plant Sciences and Agriculture, Vol. I. In-situ Conservation, CRC Press,Boca Raton, Florida, USA.
9. Cronquist, A. 1981.An Integrated System of Classification of Flowering Plants. Columbia University Press,New York, USA.
10. Directory of Indian Wetlands, 1993. WWF INDIA, New Delhi and AWS, Kuala Lumpur. Dodds, J.H. 1991. In vitro method for Conservation of Plant Genetic Resources. Springer Falk, D.A., Olwell, M. and Millan, C. 1996. Restoring Diversity, Island Press, Columbia, USA.
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12. Gadgil, M. and Guha, R. 1996. Ecology and Equity: Use and Abuse of Nature in Contemporary India. Penguin,New Delhi.
13. Gaston, K.J. (ed). Biodiversity: A Biology of Numbers and Differences, Blackwell Science Ltd., Oxford,
14. U.K. Gomez, A. Kwanchai and Gomez, A. Arturo. 1984. Statistical Procedures for Agricultural Research (second Edition), John Wiley & Sons, New York
15. Guerrant, E.O., Havens, K. and Maunder, M. 2004. Ex situ Plant Conservation. Island Press. Hamilton, A. 2013. Plant Conservation: An Ecosystem Approach. Routedge.
16. Henry, R.J. 2010. Plant Resources for Food, Fuel and Conservation. Earthscan.
17. Heywood, V. (ed) 1995. Global Biodiversity Assessment. United Nations Environment Programme. Cambridge University Press, Cambridge, U.K.

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Four Year Undergraduate Programme (Botany) Syllabus, Semester-VII	
Session 2029-2030	
Part-A Introduction	
Subject	**Botany**
Semester	**VII**
Name of the Course	Fundamentals of Nanotechnology
Course Code	**08/BOT/DSE/415T**
Course Type:	DSE
Level of the course (As per Annexure-I)	400-499
Advance Courses	
Course Learning Outcomes (CLO)	After completing the course: CLO1: Gain a comprehensive understanding of the fundamental principles of nanoscience and nanoscale properties of materials. CLO2: Acquire knowledge of nanoparticle synthesis methods, including physical, chemical, and green biological approaches using microbes and plants. CLO3: Develop an in-depth understanding of key characterization techniques used in nanotechnology. CLO4: Gain specialized knowledge of multidisciplinary applications of nanotechnology in science and industry. CLO5: Develop skills in evaluating and applying nanotechnology concepts for practical and research-oriented problems.
Credits	3+1=4
Total Marks	15+60=75 Theory and 5+20=25 Practical; Total Marks=100
Part-B Contents of the Course	
Total lecture per week	3Theory+2Practical=5hr

Units	**Topics**	**No. of Lecture/Contact Hours**
I	Fundamentals of the Nanoscale: History and background of Nanoscience; the "Size Effect", Classification of Nanomaterials, nanocrystals, Carbon Nanotubes (CNTs), Graphene, Nanoclusters and Nanowires.	9
II	Synthesis of nanoparticles: Top-Down vs. Bottom-Up; Mechanical Methods: High-energy ball milling, attrition, and grinding. Physical Methods: Laser ablation, Sputtering, Chemical Vapor Deposition, and Physical Vapor Deposition.	9
III	Chemical Methods: Sol-gel process, Microemulsions, and Hydrothermal synthesis. Green Synthesis and Biomineralization: Microbial nanoparticle production; Phytosynthesis	9
IV	Applications of Nanotechnology: Nanomedicine & Drug Delivery: Solid Lipid Nanoparticles (SLNs), Polymeric NPs, and Dendrimers. Agricultural Nanotechnology: Precision farming; Nanofertilizers; Nanopesticides; Bio-inspired Materials: Bio-matrix based on phospholipids and biomimetic polymers.	9
V	Instrumentation in Nanotechnology (working principle and application): X-Ray Diffraction (XRD) and EDX; Scanning Electron Microscopy (SEM) and Transmission Electron Microscopy (TEM); FTIR spectroscopy.	9

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Laboratory exercises

Credits	Hours	Marks	Total Hr
1	2	5+20=25	30

1. Phytosynthesis of nanoparticles using extracts from common plants (e.g., *Azadirachta indica* or *Aloe vera*)
2. Microbial Synthesis: production of nanoparticles using non-pathogenic bacteria (e.g., Bacillus subtilis) or yeast (Saccharomyces cerevisiae).
3. Chemical Synthesis of nanoparticles.
4. Recording and interpreting UV-Vis absorption spectra of synthesized nanoparticles. Analysis of Temporal stability of nanoparticles.
5. Antibacterial activity (Agar Well Diffusion): the efficacy of synthesized silver nanoparticles against common bacteria.
6. Study the effect of different concentrations of nanoparticles on the germination of seeds (e.g., Mung bean).
7. Study of synthesized photocatalytic nanoparticles (like TiO_2 or Zinc Oxide) to degrade Methylene Blue dye under UV/Sunlight.
8. Demonstration of various instruments such as XRD, EDX, SEM, TEM etc.

Suggested Reading

1. C.M. Niemeyer and C.A. Mirkin, Nanobiotechnology: Concepts, Applications and Perspectives Wiley-VCH, 2004.
2. Charles P. Poole Jr. and Frank J. Owens, Introduction to Nanotechnology, Wiley, 2003.
3. G. Cao, Nanostructures & Nanomaterials: Synthesis, Properties &Applications, Imperial College Press, 2014.
4. S. Bandyopadhyay, Fabrication and application of Nanoamaterials, 1E, Tata Mc Graw Hills, 2019.
5. David S. Goodsell, Bionanotechnology: Lessons from Nature –Wiley-Liss.
6. K. Shukla and S. Iravani, Green Synthesis, Characterization and Applications of Nanoparticles, Elsevier, 2018.
7. S. Srivastava and A. Bhargava, Green Nanoparticles: The Future of Nanobiotechnology,Springer Nature, 2021

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Four Year Undergraduate Programme (Botany) Syllabus, Semester-VII	
Session 2029-2030	
Part-A Introduction	
Subject	**Botany**
Semester	**VII**
Name of the Course	Plant Proteomics
Course Code	**08/BOT/DSE/416T**
Course Type:	DSE
Level of the course (As per Annexure-I)	400-499
Advance Courses	
Course Learning Outcomes (CLO)	After completing the course: CLO1: learn various proteomic techniques and their applications in plant research. CLO2: gain in-depth understanding of recent advances in plant proteomics, including quantitative proteomics, and tissuespecific proteomics and proteome-informatics. CLO3: learn various aspects of plant proteomics, including sample preparation, protein separation, and analysis by mass spectrometry CLO4: analyse and interpret proteomic data using bioinformatics tools and techniques. CLO5: Gain specialized knowledge of the multidisciplinary applications of nanotechnology.
Credits	3+1=4
Total Marks	15+60=75 Theory and 5+20=25 Practical; Total Marks=100
Part-B Contents of the Course	
Total lecture per week	3Theory+2Practical=5hr

Units	**Topics**	**No. of Lecture/Contact Hours**
I	Proteomics: Introduction. Top-down and bottom-up proteomics. Shotgun proteomics. Global protein expression profiling and proteome mining: basic methods and tools. Gel-based proteomics: 2-DE workflow and data analysis, Protein identification techniques: Mass spectrometry: MALDI-TOF, sample preparation, in-gel and in-solution digestion, Peptide mass fingerprinting and MS/MS.	9
II	Quantitative proteomic analysis, DIGE, MUDPIT, ICAT, ITRAQ. Validation of proteomic data: Western Immunoblotting, ELISA, Protein-protein interaction studies: yeast two-hybrid assay	9
III	Approaches to determine Protein function. Protein chips and microarrays: Introduction and applications. Emerging trends in proteomics. Proteomics in India.	9
IV	Cell, tissue and organelle proteomics: Cell Wall/ Extracellular matrix/Apoplast proteomics/Secretomics, Nuclear proteomics, Plasma membrane/tonoplast proteomics. Application of proteomics in crop improvement.	9
V	Proteome Informatics: Protein Identification by database searching. In silico characterization of proteins for subcellular localization, domain and	9

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	motif analysis, KEGG An integrated database resource; Metabolic Pathways databases (METACYC). Structural bioinformatics: From sequence to structure: prediction of protein secondary and tertiary structure, homology modeling, tools for structure prediction, validation and visualization.	

Laboratory Exercises

Credits	Hours	Marks	Total Hr
1	2	5+20=25	30

1. Gel-based Protein profiling.
2. Demonstration of 2-DE and Western immunoblotting.
3. Protein domain analysis.
4. Homology modeling for protein 3-D structure determination.
5. WebMGA for Protein function annotation by COG database
6. Identifying metabolic pathways using KAAS (KEGG Automatic Annotation Server)
7. WebMGA for tRNA prediction using tRNAscan-SE program

Suggested Reading

1. Lieber, DC (2006) Introduction to Proteomics: Tools for New Biology. Humana Press, NJ.
2. Pennington SR, Dunn MJ (Eds.) (2002) Proteomics: From Protein Sequence to Function.
3. BIOS Scientific Publishers, United Kingdom.
4. Jolles O and Jornvall H (eds) (2000) Proteomics in Functional Genomics. Birkhauser Verlag, Basel, Switzerland.
5. Attwood TK and Parry-Smith DJ (2004) Introduction to Bioinformatics, Pearson Education
6. (Singapore) Pvt. Ltd.
7. David E (Ed.) (2007) Plant Bioinformatics: Methods and Protocols. Humana Press, New Jersey, USA.
8. Mount DW Bioinformatics: Sequence and Genome Analysis. Cold Spring Harbor Laboratory, USA.

Suggested Readings (Laboratory Exercises)

1. Harlow and Lane D. (Eds.) 1988. Antibodies – A Laboratory Manual; Cold Spring Harbor Laboratory, USA.
2. Sambrook J and Russell DW (2001) Molecular Cloning – A Laboratory Manual, Vols I – III, Cold Spring Harbor Laboratory, USA.
3. Peter C and Rolf B (2000) Computational Molecular Biology: An Introduction. John Willey & Sons Ltd.
4. S Wu, Z Zhu, L Fu, B Niu and W Li (2011) WebMGA: a Customizable Web Server for Fast Metagenomic Sequence Analysis. BMC Genomics, 12:444.
5. Moriya Y, Itoh M, Okuda S, Yoshizawa A, and Kanehisa M (2007) KAAS: an automatic genome annotation and pathway reconstruction server. Nucleic Acids Res. 35, W182-W185.

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Four Year Undergraduate Programme (Botany) Syllabus, Semester-VIII		
Session 2029-2030		
Part-A Introduction		
Subject	**Botany**	
Semester	**VIII**	
Name of the Course	Modern Trends in Plant Systematics	
Course Code	**08/BOT/DSE/451T A**	
Course Type:	DSE	
Level of the course (As per Annexure-I)	400-499	
Advance Courses		
Course Learning Outcomes (CLO)	After completing the course: CLO1: Explain the conceptual basis of plant classification and the concept of family, genus and species and the taxonomic diversity within species. CLO2: Develop working skills in modern techniques in plant systematics CLO3: Choose appropriate tools of modern systematics for plant identification CLO4: Determine evolutionary relationship between a group of species using molecular taxonomic tools and techniques CLO5: Construct phylogenetic trees based on molecular systematic data	
Credits	3+1=4	
Total Marks	15+60=75 Theory and 5+20=25 Practical; Total Marks=100	
Part-B Contents of the Course		
Total lecture per week	3Theory+2Practical=5hr	

Units	**Topics**	**No. of Lecture/Contact Hours**
I	Definition, Concepts and theories of classification and biosystematics. Historical perspectives: Theophrastus, Linnaeus, and post-Linnaean developments; Phylogenetic classification and Angiosperm Phylogeny Group (APG) system; Hierarchy of taxonomic categories: Family, Genus, Species, Subspecies, and other infra-specific rank; Species concepts: Typological, Nominalistic, Biological, and modern initiatives (Systematic Agenda-2020)	9
II	Chemotaxonomy- Classification based on phytochemicals- phenolics, alkaloids, terpenoids and nonprotein amino acids. Serology and Taxonomy. Scope and limitations. Cytotaxonomy – chromosome number, chromosome size, chromosome banding and behaviour of chromosomes during division; Palynotaxonomy- Pollen morphological characters and their significance in taxonomy and evolution- Polarity, symmetry, NPC of pollen, exine stratification, excrescences, L/O pattern. Pollen Atlas	9
III	Micromorphology and Imaging Techniques: Study of trichomes, seeds, and other micromorphological characters; Imaging techniques: Stereo	9

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	microscopy, Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM); Microphotography and image analysis software for morphological studies; Numerical Taxonomy (Phenetics): Theory and principles- Operational Taxonomic Unit (OTU) Cluster analysis; UPGMA Methods; NTSYS, Applications, Merits and Demerits, Cluster analysis, Dendrogram.	
IV	Numerical and Molecular Systematics: Numerical taxonomy (Phenetics): OTUs, cluster analysis, UPGMA, dendrograms, NTSYS, applications, advantages, and limitations; Molecular systematics: Plant genome analysis of nuclear, chloroplast, mitochondrial; Molecular markers: RFLPs, RAPDs, AFLPs, SNPs; DNA barcoding and gene mapping.	9
V	Phylogenetics and Modern Approaches: - Nature and significance of phylogeny; homology and character polarization, phylogenetic diagrams and classification; Analysis of molecular data: sequence alignment, handling gaps, and comparative analysis, Molecular phylogeny reconstruction: Parsimony, distance, maximum likelihood, Bayesian methods; Integration of molecular, micromorphological, and palynological data in modern plant systematics	9

Laboratory exercise

Credits	Hours	Marks	Total Hr
1	**2**	**5+20=25**	**30**

1. Students should submit a review on plant classification- past to present.
2. Students should refer to research articles and find out
3. some cases where chemotaxonomic markers helped
4. Students should familiarise themselves with the application of chemical data from TLC/HPTLC/HPLC/ GC for taxonomy.
5. Semipermanent pollen preparations by acetolysis
6. method /any other alternative methods and study of different pollen morphotypes.
7. Study of plant surface attributes (trichomes/spines/etc.) / pollen characters with the help of Stereo Microscope /SEM.
8. Practical based on numerical taxonomy- Construct
9. OTU tables examining morphological characters of selected plants.
10. Construct phylogenetic trees using MEGA/PHYLIP
11. or Sequence similarity searching through NCBI/BLAST Make a phenetic cladogram through software

Suggested Reading

1. Ash, A et al (1999). Manual of Leaf Architecture 'by leaf Architecture Working Group - morphological description and categorization of dicotyledonous and net-veined monocotyledonous angiosperms by Leaf Architecture Working Group. 65p.
2. Bell, A.D (1991). Plant form- An illustrated guide to Flowering plant morphology. Oxford university press, New York, Tokyo
3. Angiosperm Phylogeny Group 2003. An update of the Angiosperm Phylogeny Group classification for theorders and families of flowering plants: APG II. Botanical Journal of the Linnaean Society 141: 399-436.
4. Besse, P. 2014. Molecular Plant Taxonomy: Method and Protocols. Humana Press.
5. Crank, Q.C.B., Bateman, R. M. And Hawkins, J. A. 2002. Developmental genetics and Plant Evolution. Taylorand Francis Inc. USA and Canada
6. Crawford, D.J. 2003. Plant Molecular Systematics. Cambridge University Press, Cambridge, UK. Garamszegi, L.Z. 2014, Modern phylogenetic comparative methods and their

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application in evolutionary biology -Concepts and Practice. Springer
7. Gurcharan Singh, 2010. Plant Systematics: An Integrative Approach. Science Publishers, Enfield, NH,
8. USA
9. Hall B.G. 2004, Phylogenetic Tree Made Easy-A How- to Manual. Sinauer Associates Inc. Publisher Sundarland, Massachusettes, U.S.A
10. Hamilton A. 2014, The evolution of phylogenetic systematics. University of California, Press
11. Harris, J.G. and Harris, M.W. 2001. Plant identification terminology: An illustrated Glossory. Spring Lake Pub.Hollingsworth, P.M., Bateman, R.M. and Gornall, R.J. 2002. Molecular systematic and Plant Evolution. Taylorand Francis, London and Newyork.
12. Judd, W.S., C.S. Campbell, E.A. Kellogg, P.F.Stevens and M.J. Donoghue 2002. Plant Systematics: Aphylogenetic Approach. Sinauer Associates, Inc., Massachusetts.
13. Lemey P., Salemi M., Vandamme A-M. 2009, The phylogenetic handbook: A practical approach tophylogenetic analysis and hypothesis testing. Cambridge University Press.
14. Nei, M. and S. Kumar 2000. Molecular Evolution and Phylogenetics. Oxford University Press, NewYork.
15. Pellen R., Grandcolas P. 2016, Biodiversity, conservation and phylogenetic systematics-Preserving ourevolutionary heritage in an extinction crisis. Springer
16. Radford, A. E., W.C. Dickison, J.R. Massey and C.R. Bell 1974. Vascular Plant
17. Roderic D.M., Holmes E.C. 1998, Molecular Evolution: A phylogenetic Approach. Blackwell Publishing Ltd. Scott-Ram, N.R. 1990. Transformed Cladistics, Taxonomy and Evolution.Cambridge University Press.
18. Semple, C. and Steel M.A. 2003. Phylogenetics. Oxford University Press, Oxford.38 Simpson M.G. 2013, Plant Systematics-Laboratory manual. San Diego State University Simpson, M.G. 2010. Plant Systematics. Elsevier, Amsterdam.
19. Soltis D. et al., 2018, Phylogeny and Evolution of the Angiosperm, Revised & updated edition, University ofChicago Press, Chicago & London
20. Soltis, P.S., Soltis, D.E. and Doyle, J. J. 1992. Molecular Systematics of Plants. Chapman and Hall Stuessy, T.F. 2009. Plant Taxonomy: The systematic Evaluation of Comparative Data. Columbia UniversityPress, New York.
21. Wiely, E.O. Libermann R. S. 2011, Phylogenetics: Theory and practice of phylogenetic systematics. Wiely-Blackwell Publication

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Four Year Undergraduate Programme (Botany) Syllabus, Semester-VIII	
Session 2029-2030	
Part-A Introduction	
Subject	**Botany**
Semester	**VIII**
Name of the Course	Population Biology
Course Code	**08/BOT/DSE/452T**
Course Type:	DSE
Level of the course (As per Annexure-I)	400-499
Advance Courses	
Course Learning Outcomes (CLO)	After completing the course: CLO1: Learn about population growth models, including density-independent and density-dependent factors. CLO2: Gain knowledge of population genetics, including Hardy-Weinberg principle, forces shaping genetic variation, and quantitative genetics. CLO3: Learn about plant demography, population dynamics, life tables, and species interactions. CLO4: Gain knowledge of competition (intra/inter-specific, Lotka-Volterra, exclusion principle) and allelopathy mechanisms. CLO5: Develop skills in analyzing evolutionary ecology concepts, including species coexistence and mutualism models.
Credits	3+1=4
Total Marks	15+60=75 Theory and 5+20=25 Practical; Total Marks=100
Part-B Contents of the Course	
Total lecture per week	3Theory+2Practical=5hr

Units	**Topics**	**No. of Lecture/Contact Hours**
I	Population and Growth Models: Concepts in population biology, Theories of Evolution, Population growth models: Density independent and density dependent.	9
II	Population Genetics: Gene frequencies: The Hardy-Weinberg Principle; Genetic variation in population: Polygenic inheritance and natural selection; Quantitative genetics and heritability. Role of mutation, migration, selection, and drift in shaping genetic variation.	9
III	Demography: Population dynamics of plants. Regulation of plant population; Interaction in mixture of species. Lifetables and their components.	9
IV	Competition and Allelopathy: Competition: Intra and Inter–specific and Models- Lotka-Volterra, Competitive exclusion Principle. Allelopathy: mode of release, allelochemicals and their role in ecosystems.	9
V	Evolutionary Ecology: Species coexistence; Evolution of mutualism – Basic models; Concepts of Evolutionary ecology.	9

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Laboratory/field exercises

Credits	Hours	Marks	Total Hr
1	2	5+20=25	30

1. To determine whether a population is in Hardy–Weinberg equilibrium using chi-square test.
2. To estimate allele and genotype frequencies for a given character in a natural population.
3. Measurement of growth for fitting growth curve and estimating specific growth rate:
a. Soil fungi
b. Any two wild weedy annual species
4. To prepare and analyze population growth curves (exponential and logistic).
5. To estimate carrying capacity (K) and population doubling time using growth data.
6. To study population density and dispersion pattern (random, uniform, clumped) using quadrat method.
7. To measure seedling natality and mortality rates in two weedy dicots.
8. To construct life tables, survivorship curves, and estimate life expectancy.
9. To analyze age/size structure of plant populations using field data.
10. To measure dominance, diversity, and evenness of vegetation (e.g., desert/grassland).
11. To estimate niche width and resource utilization for trees/shrubs/annuals.
12. To study interspecific interactions (competition/association) using field data or simple models.
13. To perform simulation studies of genetic drift, bottleneck, and founder effects.
14. To estimate heritability using ANOVA (RBD) or parent–offspring regression.
15. To prepare a stage-structured (Leslie matrix) population model and project population growth.

Suggested Readings

1. Barbour, M.G. Burk, J.H. and Pitts, W.D. 1987. Terrestrial Plant Ecology, Benjamin/Cummings Publication Company, California.
2. Begon, M. Harper, J.L. and Townsend, C.R. 1996. Ecology. Blackwell Science, Cambridge, U.S.A. Britton, N.F.
3. 2003. Essential Mathematical Biology Springer International Edition, 335 pp.
4. Brooker, R.J. 1999. Genetics – Analysis and Principles. Benjamin/Cummings an imprint of AddisonWestoy Longman, Inc.
5. Donovan, T.M. and Weldon, C.W. 2002. Spreadsheet Exercises in Ecology and Evolution. Sinauar Associates Inc. Publ. Sunderland, Massachusetts, USA, 556 pp.
6. Freysen, A.H.J. and Woldendrop, J. 1978. Structure and Functioning of Plant Populations (eds.), North Holland Publ. Co., Amsterdam.
7. Harper, J.L. 1977. Population Biology of Plants. Academic Press, London and New York. Hastings, A. 1997.
8. Population Biology: Concepts and Models. Springer Publication.
9. Krebs, C.J. 1989. Ecological Methodology. Harper and Row, New York, USA. Ludwig, J.A. and Raynolds, J.F.
10. 1988. Statistical Ecology, Wiley, New York.
11. Neel, D. 2004. Introduction to Population Biology, Cambridge University Press, 393 pp.

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Four Year Undergraduate Programme (Botany) Syllabus, Semester-VIII		
Session 2029-2030		
Part-A Introduction		
Subject	**Botany**	
Semester	**VIII**	
Name of the Course	Environment Monitoring, Management and Restoration	
Course Code	**08/BOT/DSE/453T C**	
Course Type:	DSE	
Level of the course (As per Annexure-I)	400-499	
Advance Courses		
Course Learning Outcomes (CLO)	After completing the course: CLO1: Learn about types, sources, and effects of environmental pollution (air, water, soil, noise, thermal, radioactive) on plants, animals, and buildings. CLO2: Gain knowledge about environmental pollution in arid Rajasthan, including dust storms, salinity, agrochemicals, fluoride, heavy metals, and industrial impacts. CLO3: Learn about climate change, greenhouse effect, ozone depletion, acid rain, and sea level rise, and basic environmental and biomonitoring methods. CLO4: Gain knowledge of disturbed ecosystems, restoration strategies, phytoremediation, and acceleration of ecological succession. CLO5: Develop skills in analyzing sustainable development and practices in arid Rajasthan, including traditional and modern water-harvesting and greening systems.	
Credits	3+1=4	
Total Marks	15+60=75 Theory and 5+20=25 Practical; Total Marks=100	
Part-B Contents of the Course		
Total lecture per week	3Theory+2Practical=5hr	

Units	**Topics**	**No. of Lecture/ Contact Hours**
I	Pollution: Definition, Kinds, Sources, quality parameters; Air, Water, Soil, Radioactive, Noise and Thermal Pollution. Effects on plants, animals and buildings and their control. Environmental Pollution in Arid Rajasthan; Dust storms, particulate matter (natural + anthropogenic), Soil pollution; Salinity due to irrigation, Agrochemicals in canal-irrigated zones Water pollution, Fluoride contamination, Salinity and heavy metals in groundwater, Industrialization (cement, textiles)	9
II	Climate Change: Greenhouse effect and global warming; Ozone depletion; UV radiations; acid rain and Sea level rise. Environmental monitoring; Biomonitoring and Bioindicators.	9
III	Ecology of Disturbed Ecosystems: Wastelands: Description and Classification. Disturbance and its impact on the structure and functioning of terrestrial and aquatic ecosystems. Environmental impacts of mining and industrialization. Mining in Rajasthan (gypsum, limestone), Urban expansion	9

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	Arid Ecosystems of Rajasthan; Increased aridification and wind erosion, Groundwater depletion and salinization, Expansion of desert margins, Role of Aravalli Range degradation	
IV	**Restoration:** Aims and strategies of restoration; physical, chemical, biological and biotechnological tools of restoration. Phytoremediation of disturbed ecosystems; Acceleration of ecological succession, reintroduction of biota.	9
V	Management: Introduction and scope of basic concepts of sustainable development: Definition, concepts, capitals, currencies, problems and integration. Indicator for sustainable Development. Sustainable Practices in Arid Rajasthan; Traditional systems: Khadin system, Tanka, Nadi, Baori (rainwater harvesting) ; Modern interventions: Desert afforestation, Dune stabilization, Micro-irrigation (drip, sprinkler) Case study: Indira Gandhi Canal Project, Greening of desert	9

Laboratory exercise

Credits	Hours	Marks	Total Hr
1	**2**	**5+20=25**	**30**

1. To determine the chlorophyll a, b and total chlorophyll contents of the given plant samples growing in polluted and non-polluted environments.
2. To determine proline contents of the given plant samples growing in polluted and non-polluted environments.
3. To calculate the percentage of the injured area in the leaves provided to you.
4. To calculate the dust capturing capacity of the leaves provided to you.
5. To estimate the organic carbon content of soil using modified Walkley and Black's rapid titration.
6. To quantitatively assess available phosphorus in given soil samples.
7. To quantify carbonate and bicarbonate concentration in water samples.
8. To quantitatively assess Chloride concentration by argentometric method in water samples.
9. To estimate salinity of water sample using chlorosity.
10. To estimate Dissolved Oxygen (DO) in different depths (0 and 15cm) of two water bodies.
11. Case Study on Indira Gandhi Canal Project or Greening of desert and submit a comprehensive report of it.

Suggested Reading

1. Bradshaw, A.D. and Chadwick, M.J. 1980. The Restoration of Land. Blackwell Scientific Publications,Oxford.
2. Singh, A. and Ward, O.P. (Eds.). Applied Bioremediation and Phytoremediation. Springer. 2004. Abrol, I.P. and Dhruva Narayan, V.V. (Eds.). Technologies for Wasteland Development. ICAR, New Delhi.1998.
3. Owen, S.O. and Chiras, D.D. 1990. Natural Resource Conservation: An Ecological Approach. Macmillan USA; 5th edition. url: www.iucn.org for Global Biodiversity.
4. Acevedo, M. F. (2024). Real-time environmental monitoring: Sensors and systems (2nd ed.). CRC Press.
5. Bathiany, S., Bastiaansen, R., Bastos, A., et al. (2025). Ecosystem resilience monitoring and early warning using Earth observation data: Challenges and outlook. Springer. https://doi.org/10.1007/s10712-024-09833-z
6. Centre for Science and Environment. (2025). State of India's environment 2025: In figures. Centre for Science and Environment. ISBN 978-81-984866-0-8.
7. Das, A., Das, S., & Mahapatra, R. L. (Eds.). (2025). The Bharat blueprint: India's solutions to the global environmental crisis. ISBN 978-81-989555-3-1. https://doi.org/10.52756/tihlgc.2025.e01
8. Florinsky, I. (2025). Digital terrain analysis in soil science and geology (3rd ed.). Elsevier. ISBN 9780443247989.
9. Future Earth, The Earth League, & World Climate Research Programme. (2024). 10 new insights in climate science 2024/2025. https://doi.org/10.5281/zenodo.14035986
10. Manning, A. (2026). Rebuilding an ecosystem: Integrating applied research and restoration. ANU Press.

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Four Year Undergraduate Programme (Botany) Syllabus, Semester-VIII	
Session 2029-2030	
Part-A Introduction	
Subject	**Botany**
Semester	**VIII**
Name of the Course	Applied Molecular and Biotechnology
Course Code	**08/BOT/DSE/454T**
Course Type:	DSE
Level of the course (As per Annexure-I)	400-499
Advance Courses	
Course Learning Outcomes (CLO)	After completing the course: CLO1: learn applied aspects of plant biotechnology. CLO2: know about biotechnology industries in India. CLO3: gain knowledge about bio-analytics and biosensor technology. CLO4: know about the molecular biotechnogy. CLO5: understand IPR and ethics of patenting plant biotechnology.
Credits	3+1=4
Total Marks	15+60=75 Theory and 5+20=25 Practical; Total Marks=100
Part-B Contents of the Course	
Total lecture per week	3Theory+2Practical=5hr

Units	**Topics**	**No. of Lecture/ Contact Hours**
I	Applications of plant biotechnology in agriculture, horticulture, forestry and pharmaceuticals. Biotechnology parks/incubators in India. Public private partnership in biotechnology industry in India: Biotechnology industry research assistance council (BIRAC).	9
II	*In vitro* production of secondary metabolites/natural plant products: various types of suspension cultures and bioreactors. Strategies for optimization of *in vitro* production of secondary metabolites. Hairy root culture. Biotransformation. *In vitro* production of Ginseng and Shikonin as a model system for industries. Commercial aspects of *in vitro* production of plant products.	9
III	Bioanalytics: Idenfication and structural elucidation of pharmaceutical and nutritionally important plant metabolites using chromatography, Mass spectrometery and NMR spectrometery. Detrmination of characteristics of plant constituents: Markers, Near infra-red spectroscopy (NIRS), Solid phase microextraction (SPME), ELISA, Spectrophotmeteric color measurement.	9
IV	Plant molecular biotechnology: Plant cultivar/genotype identification by nuclear/organellar genome/isozyme profiling. Gene tagging and their role in yield and quality improvement. Terminator and traitor technology. Biosensor technology: principles and applications.	9
V	Intellectual Property Protection of Plant Biotechnology: Utility patents, TRIPS, Plant Variety Protection, Geographical indicators, Biotechnology directives, ethics of patenting plant biotechnology.	9

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Laboratory Exercises

Credits	Hours	Marks	Total Hr
1	2	5+20=25	30

1. Development of regeneration protocols employing direct and indirect organogenesis / somatic embryogenesis in economically important horticultural and/or medicinal plants.
2. Control of phenolics in recalcitrant tissues under culture conditions.
3. Study of various physico-chemical factors (pH, light, hormones, etc.) effecting *in vitro* growth and development of tissues or organs, rooting of regenerants, and hardening.
4. Isolation of plant products/secondary metabolites using paper and thin layer chromatography (TLC).
5. DNA profiling and genetic analyses.
6. Protein/enzyme profiling.

Suggested Readings

1. Weaver, R. F. and Hedrick, P. W. 1992. Genetics.
2. Dubuque, IA: Wm. C. Brown Publishers. Pauline, M. D. 1997. Hairy Roots: Culture and Applications. Harwood Academic Publishers.
3. Peter, C. and Rolf, B. 2000.Computational Molecular Biology: An Introduction. John Willey & Sons Ltd.
4. Brown, T.A. 1999. Genomes. John Wiley & Sons (Asia) Pvt. Ltd., Singapore.
5. Phillips, R. L. and Vasil, I. K. 1994. DNA- Based Markers in Plants. Kluwer Academic Publishers.
6. Schena, M. 1996. DNA microassays (A Practical Approach).Oxford University Press.
7. Woung-Young, S. and Bhojwani, S. S. 1999.Morphogenesis in Tissue Cultures (ed.). Kluwer Academic Publishers.
8. Herman EB (2008) Media and Techniques for Growth, Regeneration and Storage 2005-2008. Agritech Publications, New York, USA.
9. Pierik RLM (1999) *In Vitro* Culture of Higher Plants. Kluwer Academic Publishers.
10. George EF, Hall MA and Geert-Jan De Klerk (2008). Plant Propagation by Tissue Culture (3rd Edition), Springer, Netherlands.
11. Bhojwani, S.S. Plant Tissue Culture: Application and Limitation, Elsevier Science Publishers, New York, USA, 1990.
12. Raghavan, O. Embryogenesis in Angiosperms: A Developmental and Experimental Study, CambridgeUniversity, Press, New York, USA, 1986.
13. Vasil, I.K. and Thorpe, T.A. Plant Cell and Tissue Culture, Kluwer Academic Publishers, The Netherlands, 1994.

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Four Year Undergraduate Programme (Botany) Syllabus, Semester-VIII	
Session 2029-2030	
Part-A Introduction	
Subject	**Botany**
Semester	**VIII**
Name of the Course	Crop Genetics and Plant Breeding
Course Code	**08/BOT/DSE/455T**
Course Type:	DSE
Level of the course (As per Annexure-I)	400-499
Advance Courses	
Course Learning Outcomes (CLO)	After completing the course: CLO1: Understand principles, history, and importance of plant breeding and breeding systems. CLO2: Gain knowledge of sources of variation, including mutations, polyploidy, somaclonal variation, and gene pools. CLO3: Learn conventional breeding methods, heterosis, inbreeding depression, heritability, and genetic advance. CLO4: Explain molecular breeding tools: molecular markers, QTL mapping, and marker-assisted selection. Understand novel breeding techniques (TALENs, CRISPR-Cas9) and applications in crop improvement. CLO5: Learn plant intellectual property rights, plant variety protection, and farmers' rights.
Credits	3+1=4
Total Marks	15+60=75 Theory and 5+20=25 Practical; Total Marks=100
Part-B Contents of the Course	
Total lecture per week	3Theory+2Practical=5hr

Units	Topics	No. of Lecture/Contact Hours
I	**Plant Breeding:** Introduction, History and Importance of plant breeding; Breeding systems in crop plants; Self-incompatibility, male sterility and apomixis, Important achievements in plant breeding.	9
II	**Sources of Variation:** Plant genetic resources-their management and conservation, utilization of gene pools in breeding programs. Chromosome manipulation-induced mutations, haploidy, polyploidy; somatic hybridization, somaclonal variations.	9
III	**Conventional Breeding Methods:** Selection and hybridization methods for self-pollinated, cross-pollinated and vegetatively propagated crops-procedure, advantages and limitations. Heterosis Breeding: Genetic and molecular basis of heterosis (hybrid vigour); Development of hybrid varieties. Inbreeding depression. Heritability and Genetic Advance.	9
IV	**Molecular Genetics and Plant Breeding:** Molecular markers; Principle of genetic linkage and genetic distance; Elimination of linkage drags; Development and choice of mapping populations; Linkage map construction; QTL mapping: Principles and methods, QTL Introgression;	9

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	Marker-assisted breeding: Marker Assisted Selection; Marker assisted recurrent selection, Gene tagging. Novel Plant Breeding Tools: TALEN's, CRISPR-Cas9, Base editing.	
V	**Intellectual Properties:** Intellectual Property Rights (IPR), Patenting; UPOV convention; Plant Breeder's Right, Release of New Varities-Trials and evaluation, Prerelease, Notification and Release; Plant Variety Protection; Farmer's Right.	9

Practical Exercises

Credits	Hours	Marks	Total Hr
1	**2**	**5+20=25**	**30**

1. Floral biology in self and cross-pollinating crops
2. Selfing and crossing techniques in major field crops
3. Determination of extent of outcrossing
4. Male sterility - Detection and maintenance
5. Self-incompatibility: Techniques of maintaining and overcoming sporophytic and gametophytic incompatibility
6. Screening for quality traits
7. Demonstration of quality seed production through nucleus and breeders seed production techniques
8. Induction of polyploidy in plant.
9. Study of mutagens on biochemicals/pigments.

Suggested Readings

1. Acquaah G (2007). Principles of Plant Genetics and Breeding, Blackwell Publishing Ltd. USA.
2. Allard RW (1999). Principles of Plant Breeding (2nd Edition), John Wiley and Sons, ISBN 0471023094, 9780471023098.
3. Fehr, W.R. 1987. Principles of Cultivar Development (2 Volumes). Mac Millan Publishing Co., New York.
4. Lewin B (2008). Genes IX, Jones and Barlett Publishers, ISBN-10: 0763740632.
5. Poehlman, J.M. 1986, Breeding Field Crops. AVI Publishing Company, Connecticut.
6. Simmonds (1995). Evolution of Crop Plants (2nd Edition) Longman.
7. Singh, B.D. 2000. Plant Breeding-Principles and Methods. Kalyani Publsihers, New Delhi.
8. Essentials of Plant Breeding
9. Singh P (2018) Essentials of Plant Breeding. Kalyani Publishers, New Delhi.
10. Yunbi X (2010) Molecular Plant Breeding. CABI.
11. Gupta OP, Karkute SG (2021) Genome Editing in Plants: Principles and Applications. CRC Press
12. Pandey N, Dharni K (2014) Intellectual Property Rights. PHI Learning.
13. Theoretical and Applied Genetics: For high-level molecular mapping and QTL insights

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Four Year Undergraduate Programme (Botany) Syllabus, Semester-VIII	
Session 2029-2030	
Part-A Introduction	
Subject	**Botany**
Semester	**VIII**
Name of the Course	**Agricultural Biotechnology**
Course Code	**08/BOT/DSE/456T**
Course Type:	DSE
Level of the course (As per Annexure-I)	400-499
Advance Courses	
Course Learning Outcomes (CLO)	After completing the course: CLO1: Understand how biotechnology addresses food security, climate change, and sustainability in agriculture. CLO2: Learn principles of agri-biotechnology and tools like genetic engineering and genome editing for crop improvement. CLO3: Analyze benefits and risks of agricultural biotechnology for yield, pest resistance, and the environment. CLO4: Develop skills to pursue research and critically evaluate current biotechnology literature. CLO5: Develop skills in writing reports and presenting data on agricultural biotechnology.
Credits	3+1=4
Total Marks	15+60=75 Theory and 5+20=25 Practical; Total Marks=100
Part-B Contents of the Course	
Total lecture per week	3Theory+2Practical=5hr

Units	**Topics**	**No. of Lecture/Contact Hours**
I	Recent advances in Agricultural Biotechnology: different tools and techniques of agricultural biotechnology; Genetic engineering to develop transgenic crops for herbicide-tolerance, insect-resistance, disease-resistance, abiotic stress tolerance, and nutritional quality enhancement. Genetic engineering for improving nitrogen fixation in plants.	9
II	Crop improvement by Post-transcriptional Gene Silencing; RNA interference: introduction to siRNA; siRNA technology; Micro RNA; construction of siRNA vectors; principle and application of gene silencing; gene knockouts and gene therapy. Introduction to Molecular breeding.	9
III	Designing climate-smart crop plants by genome editing: introduction to the related tools and techniques. Genome engineering mediated by CRISPR-CAS: workflow and applications for development of tolerance for salinity, drought, and oxidative stress in agriculturally important plants.	9
IV	Mining candidate genes for crop improvement through "*omics*" technology. Introduction to the various *-omics* approaches: transcriptomics/Next Generation Sequencing (NGS), proteomics and metabolomics, workflow and applications.	9

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V	Success stories of genetically modified and genome edited plants for crop improvement: Tobacco, cotton, tomato and rice as model systems. Concerns of Genetically Modified crops: Adverse effects on non-target organisms, Resistance breakdown. Risks, benefits and ethics, Bio-safety concerns of transgenic plants; Global status of GM crops approved for commercialization.	9

Laboratory exercise

Credits	Hours	Marks	Total Hr
1	**2**	**5+20=25**	**30**

1. Agrobacterium-mediated plant genetic transformation
2. Techniques for molecular characterization of transgenic/genome edited plants: PCR, RT-PCR, Western immunoblotting
3. Genome editing workflow demonstration: designing of sgRNA.
4. GFP cloning
5. Comparing rhizobial genomes in JGI database using IMG-Genome portal.

Analysis of genes related to plant growth promotion (PGP) activities in rhizobial genomes.

Suggested Reading

1. Slater A, Scott NW, Fowler MR, 2008: Plant Biotechnology: The Genetic Manipulation of Plants, Second edition, Oxford
2. Gosal SS, Wani SH, 2019: Biotechnologies of Crop Improvement, Vol. 1 (DOI https://doi.org/10.1007/978-3-319-78283-6), Springer
3. Lesk A, 2017: Introduction to Genomics, third edition, OUP Oxford
4. Jolles. O and Jornvali H (eds), 2000: Proteomics in functional genomics, Birkhauser veriorg, Basel, Switzerland.
5. Henry RJ, 1997: Practical applications of Plant Molecular Biology, Chapman & Hall London, UK.
6. Primorose SB, Twyman RM, old RW, 2001: Principles of Gene Manipulation, sixth edition, Blackwell science.
7. TA Brown, 2001: Gene Cloning and DNA analysis, an introduction, Fourth edition Blackwell science.
8. Qi Y, 2019: Plant Genome Editing with CRISPR Systems: Methods and Protocols, first edition, Humana New York, NY
9. Gupta OP, Karkute SG (eds.) 2021: Genome Editing in Plants: Principles and Applications; first edition, CRC Press (Taylor & Francis group), Boca Raton.
10. Pandita D, Pandita A, 2023: CRISPR/Cas-Mediated Genome Editing in Plants, first edition, Apple Academic Press (Taylor & Francis group), New York.

Suggested Research Journals:

1. Plant Biotechnology Journal
2. Plant Cell Reports
3. Plant Science
4. The Plant Journal
5. Science
6. Nature Biotechnology
7. Critical Reviews in Biotechnology
8. Journal of Proteome Research
9. Genomics, Proteomics and Bioinformatics

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Four Year Undergraduate Programme (Botany) Syllabus, Semester-VIII	
Session 2029-2030	
Part-A Introduction	
Subject	**Botany**
Semester	**VIII**
Name of the Course	Genomics and Bioinformatics
Course Code	**08/BOT/DSE/457T G**
Course Type:	DSE
Level of the course (As per Annexure-I)	400-499
Advance Courses	
Course Learning Outcomes (CLO)	After completing the course: CLO1: Gain knowledge of genomics, including genome structure, function, and methods used to study genomes. CLO2: Learn how bioinformatics tools are used to analyze genomic data, including genome assembly and annotation. CLO3: Learn how to analyze gene expression and comparative genomics using bioinformatics methods. CLO4: Develop skills in using bioinformatics software and public sequence databases for genomic research. CLO5: Develop skills in applying computational tools, algorithms, and statistics to genomic data analysis.
Credits	3+1=4
Total Marks	15+60=75 Theory and 5+20=25 Practical; Total Marks=100
Part-B Contents of the Course	
Total lecture per week	3Theory+2Practical=5hr

Units	**Topics**	**No. of Lecture/Contact Hours**
I	Introduction to Sequencing strategies, High throughput sequencing; Next generation sequencing (NGS) platforms. Bioinformatics: Introduction and applications. Major gene and protein sequence/structure, Literature databases. Searching database and locating genes, Storage, Retrieval and analysis of sequences.	9
II	Editing/refinement of sequences. Alignment of gene/protein sequences: Local and Global. Multiple sequence alignments, Sequence similarity search. Generating phylogenetic trees based on DNA sequence and evolutionary relationship.	9
III	Genomics: Introduction, Structural, functional and comparative genomics. Genome sequence analysis, annotation and gene prediction. Major Genome sequencing projects: Arabidopsis, Model Legumes, RNB-GEBA. Selected Model Organismal Genomes and Databases; GOLD: Data resource for genomic and metagenomic projects, Phytozome.	9
IV	Plant Functional genomics: Approaches to analyze differential gene expression: Transcriptomics, microarray and its applications. Validation of transcriptome and microarray data: Analysis of differential gene expression by qRT-PCR	9

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V	Comparative Genomics: Concept, approaches and applications. Synteny; Gene search and comparison tools. Comparative genomics of model plants and related crop species. Comparative genomics of microbes. Application of genomics for crop improvement.	9

Laboratory exercise

Credits	Hours	Marks	Total Hr
1	**2**	**5+20=25**	**30**

1. Demonstration of PCR and Real time PCR.
2. Qualitative and quantitative analysis of nucleic acids using agarose gel electrophoresis and Nanodrop spectrophotometer.
3. Searching and retrieval of gene/protein sequences.
4. Multiple Sequence alignment using ClustalW
5. Similarity searching using BLAST (n and p-blast).
6. Phylogenetic tree construction using MEGA.
7. Microbial Genome Annotation using RAST
8. Estimating average nucleotide identity between two genomic datasets of microbes
9. *In silico* DNA-DNA hybridization using GGDC (Genome-to-Genome Distance Calculator)
10. Submission of nucleotide sequences at NCBI-GenBank

Suggested Readings

1. Gustafson JP (2000) Genomes. Kluwer Academic Plenum Publishers, New York, USA.
2. Brown TA (1999) Genomes. John Wiley & Sons (Asia) Pvt. Ltd., Singapore.
3. Primrose SB (1995) Principles of Genome Analysis. Blackwell Science Ltd., Oxford, UK.
4. Singer M and Berg P (1991) Genes and Genomes: A Changing Perspective. University Science Books, CA, USA.
5. Attwood TK and Parry-Smith DJ (2004) Introduction to Bioinformatics. Pearson Education (Singapore) Pvt. Ltd.
6. David E (Ed.) 2007 Plant Bioinformatics: Methods and Protocol. Humana Press, New Jersey, USA.

Suggested Readings (Laboratory Exercises)

1. Sambrook J and Russell DW (2001) Molecular Cloning – A Laboratory Manual, Vols I – III, Cold Spring Harbor Laboratory, USA.
2. Gelvin SB and Schilperoort RA (eds) (1994) Plant Molecular Biology Manual, 2nd edition, Kluwer Academic Publishers, Dordrecht, The Netherlands.
3. Glick BR and Thompson JE (1993) Methods in Plant Molecular Biology and Biotechnology. CRC Press, Boca Raton, Florida.
4. Glover DM and Harnes BD (eds) (1995) DNA Cloning: A Practical Approach. Core Techniques, 2nd edition, PAS, IRL Press at Oxford University Press, Oxford.
5. Peter C and Rolf B (2000) Computational Molecular Biology: An Introduction. John Willey & Sons Ltd.
6. The Arabidopsis Genome Initiative (2000) Analysis of the genome sequence of the flowering plant *Arabidopsis thaliana.* Nature 408:796–815
7. Tamura K, Stecher G, Peterson D, Filipski A, and Kumar S (2013) MEGA6: Molecular Evolutionary Genetics Analysis Version 6.0. Molecular Biology and Evolution 30: 2725-2729.
8. Aziz RK, Bartels D, Best AA, DeJongh M, Disz T, et al (2008) The RAST Server: rapid annotations using subsystems technology. BMC Genomics. 8;9:75.
9. Meier-Kolthoff JP, Auch AF, Klenk HP, Göker M (2013) Genome sequence-based species delimitation with confidence intervals and improved distance functions. BMC Bioinformatics 14:60
10. Goris J, Konstantinidis KT, Klappenbach JA, Coenye T, Vandamme P, Tiedje JM (2007) DNA-DNA hybridization values and their relationship to whole-genome sequence similarities. Int J Syst Evol Microbiol. 57(Pt 1):81-91.

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Four Year Undergraduate Programme (Botany) Syllabus, Semester-VIII	
Session 2029-2030	
Part-A Introduction	
Subject	**Botany**
Semester	**VIII**
Name of the Course	Advanced Plant Physiology
Course Code	**08/BOT/DSE/461T**
Course Type:	DSE
Level of the course (As per Annexure-I)	400-499
Advance Courses	
Course Learning Outcomes (CLO)	After completing the course: CLO1: Understand advanced physiological processes in plant growth, development, and reproduction. CLO2: Learn mechanisms of plant responses to abiotic and biotic stress, including water, nutrient, and hormone signaling. CLO3: Analyze molecular and biochemical mechanisms underlying photosynthesis, secondary metabolite production, and photobiology. CLO4: Apply advanced techniques in plant physiology research, including chromatographic, spectrophotometric, and enzymatic methods. CLO5: Critically evaluate experimental data in plant physiology and use scientific tools for research applications.
Credits	3+1=4
Total Marks	15+60=75 Theory and 5+20=25 Practical; Total Marks=100
Part-B Contents of the Course	
Total lecture per week	3Theory+2Practical=5hr

Units	**Topics**	**No. of Lecture/Contact Hours**
I	Enzyme principles, isozymes, regulation, and applications in plant biology; Biocatalytic reactions and enzyme technology; Evolution and functioning of electron transport chains and ATP synthesis.	9
II	Signal transduction: receptors, second messengers, G-proteins, cyclic nucleotides, Ca^{2+}-calmodulin cascade, two-component systems; Molecular basis of water, ion, and molecule transport: apoplastic/symplastic pathways, aquaporins, ion channels, ABC transporters, ATPases.	9
III	Photosynthesis: light-harvesting systems, electron transport, photophosphorylation, C3, C4, CAM pathways, RUBISCO, photorespiration; Photobiology: phytochromes, cryptochromes, phototropins, photomorphogenesis, circadian regulation; N_2 fixation and molecular mechanisms	9
IV	Plant hormones: auxins, gibberellins, cytokinins, ABA, jasmonic acid – structure, effects, and modes of action; Flowering, floral induction, evocation, development; seed germination and dormancy; fruit ripening and senescence; Secondary metabolites: phenolics, alkaloids, carotenoids, anthocyanins, metabolic engineering for pharmaceuticals.	9

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V	Spectrophotometry, chromatography (TLC, HPLC, GC, ion-exchange), electrophoresis, isoelectric focusing; Ultracentrifugation: velocity and density gradient methods; Application of techniques in studying photosynthesis, enzymatic activity, metabolite profiling, and secondary metabolite production.	9

Laboratory exercise

Credits	Hours	Marks	Total Hr
1	**2**	**5+20=25**	**30**

1. Preparation of buffers and enzyme extracts.
2. Assay of acid phosphatase activity in germinating seedlings.
3. Enzyme purification and determination of kinetics (Km and Vmax).
4. Time- and protein-linearity analysis of enzyme reactions.
5. Enzyme immobilization techniques.
6. Isolation of chloroplasts using density gradient centrifugation.
7. Separation and quantification of plant pigments (photosynthetic pigments, anthocyanins) using chromatography and spectrophotometry.
8. Stomatal analysis in xerophytes: index, frequency, and percentage of open area.
9. Estimation of soluble sugars, amino acids, and proline in plant tissues.
10. Photosynthetic pigment and total phenol analysis in senescent leaves.
11. Nitrate reductase (NR) and nitrite reductase (NiR) activity assays.

In vitro seed germination and biochemical analysis of germinating seeds/seedlings.

Suggested Reading

1. Taiz, L., Zeiger, E., Møller, I. M., & Murphy, A. (2022). *Plant Physiology and Development* (7th ed.). ISBN: 978-0197577240. Publisher: Oxford University Press / Sinauer Associates.
2. Ahmad, P., & Wani, M. R. (Eds.). (2014). *Physiological Mechanisms and Adaptation Strategies in Plants Under Changing Environment*. ISBN: 978-1461486101. Publisher: Springer New York.
3. Hopkins, W. G., & Hüner, N. P. A. (2020). *Introduction to Plant Physiology* (5th ed.). ISBN: 978-1119603797. Publisher: John Wiley & Sons.
4. Salisbury, F. B., & Ross, C. W. (2021). *Plant Physiology* (6th ed.). ISBN: 978-1119806213. Publisher: Wiley.
5. Nobel, P. S. (2023). *Physicochemical and Environmental Plant Physiology* (5th ed.). ISBN: 978-0128214548. Publisher: Academic Press / Elsevier.
6. Tripathi, B. N., & Müller, M. (Eds.). (2022). *Stress Responses in Plants: Mechanisms of Toxicity and Tolerance* (2nd ed.). ISBN: 978-3031008876. Publisher: Springer.
7. Singhal, G. S., et al. (2020). *Concepts in Photobiology: Photosynthesis and Photomorphogenesis* (Updated ed.). ISBN: 978-9811531726. Publisher: Springer / Narosa Publishing House.
8. Hooykaas, P. J. J., Hall, M. A., & Libbenga, K. R. (Eds.). (2021). *Biochemistry and Molecular Biology of Plant Hormones* (3rd ed.). ISBN: 978-9400709554. Publisher: Springer.
9. Dennis, D. T., et al. (Eds.). (2020). *Plant Metabolism* (3rd ed.). ISBN: 978-3030614143. Publisher: Springer.
10. Hemantaranjan, A. (Ed.). (2024). *Advances in Plant Physiology (Vol. 15)* (Revised ed.). ISBN: 978-8172339364. Publisher: Scientific Publishers, Jodhpur.
11. Wilkins, M. B. (Ed.). (2023). *Advanced Plant Physiology* (Reprint ed.). ISBN: 978-1032653620. Publisher: CRC Press / Taylor & Francis.

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Four Year Undergraduate Programme (Botany) Syllabus, Semester-VIII	
Session 2029-2030	
Part-A Introduction	
Subject	**Botany**
Semester	**VIII**
Name of the Course	Genetic Engineering of Plants
Course Code	**08/BOT/DSE/462T**
Course Type:	DSE
Level of the course (As per Annexure-I)	400-499
Advance Courses	
Course Learning Outcomes (CLO)	After completing the course: CLO1: understand basic tools and techniques of genetic engineering. CLO2: use methods and techniques involved in manipulation. CLO3: analyze nucleic acids and DNA fingerprinting. CLO4: clone gene and creation of genetically modified organisms (GMOs). CLO5: understand the commercial application of rDNA technology in research, agriculture and human health.
Credits	3+1=4
Total Marks	15+60=75 Theory and 5+20=25 Practical; Total Marks=100
Part-B Contents of the Course	
Total lecture per week	3Theory+2Practical=5hr

Units	**Topics**	**No. of Lecture/Contact Hours**
I	Genetic Engineering: basic concept and definition. DNA technology and gene cloning. Enzymes in geneticengineering: Restriction endonucleases, exonucleases, polymerases, RNAses, kinases, ligases.Gene cloning vectors:Plasmids (pBR322, pUC18, pUC19); Lambda based vectors and derivatives (Insertion, replacement, cosmids and phagemid vectors); Artificial Chromosomes (YACs, BACs).	9
II	Bacterial transformation, strategies for selection and screening (α complementation, antibiotic resistance). *Agrobacterium tumafaciens*: natural genetic engineer; molecular biology and strategies for genetic manipulation in plants.Protein Expression Vectors for use in *E. coli*;introduction to marker and reporter genes (GUS, GFP).Gene transfer methods: *Agrobacterium* mediated transformation, Electroporation,Microinjection, Particle Bombardment, PEG mediated.	9
III	DNA libraries construction and screening: Procedures for construction of genomic and cDNA libraries, screening methods for locating the desired gene (Replica plating, Complementation screening, heterologous gene probe-based hybridizations).	9
IV	PCR, nucleic acid hybridization and DNA sequencing: PCR technique and its applications, RTPCR,qPCR, Hybridization based assays (Southern and Northern blotting), Sanger's di-deoxy chain termination method of sequencing – gel-based electrophoresis (semi-automated) and capillary-based gel electrophoresis (automated sequencing).	9

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V	Applications of genetic engineering (rDNA technology): Applications in basic research (identify, map, clone, andsequence genes and to determine their functions); applications in agriculture (golden rice, *Bt*cotton); applications inhuman health and therapeutics. Human genome project and sequencing of plant genomes bytaking Arabidopsis genome as an example. Safety and Ethical Issues related to rDNA research.	9

Practical Exercises

Credits	Hours	Marks	Total Hr
1	**2**	**5+20=25**	**30**

Major

1. Isolation of plant genomic DNA.
2. Quantitative estimation of plant genomic DNA using UV/VIS spectrophotometer.
3. Preparation of agarose gel and loading of genomic/PCR amplified DNA.
4. Isolation and quantification of genomic/plasmid DNA from bacterial/yeast.
5. Preparation of PCR reaction mixer for amplification of DNA using primers.
6. Scoring of PCR amplified DNA bands and preparation of dendrogram.

Minor

1. DNA sequencing by Sanger's di-deoxy chain termination method.
2. Experimental designing of selection and screening of antibiotic resistance.
3. Construction of artificial chromosome (YAC, BAC)
4. Experimental setup of RT/q-PCR.
5. Experimental setup of hybridization-based assay (blotting) of DNA, RNA and protein.
6. Cleavage DNA using specific restriction enzymes and construct restriction map.

Spots

1. Agarose electrophoresis Unit, RT-PCR
2. Vectors: pBR, pUC, Artificial chromosome
3. Gene transfer method: Microinjection, Particle gun, Electroporation, Ti plasmid mediated gene transfer
4. Blotting
5. cDNA libraries
6. Recombinant Insulin
7. Human growth hormone
8. Next-generation sequencing
9. Transgenic Plant: Golden rice, Bt cotton, Flavrsavr tomato, Edible vaccine
10. Gene editing

Suggested Readings:

1. M. R. Green, J. Sambrook. Molecular Cloning: A Laboratory Manual (Cold Spring Harbor, ed. 4, 2012).

2. M. Wink. An Introduction to Molecular Biotechnology: Molecular Fundamentals, Methods and Applications in Modern Biotechnology (Wiley, ed. 2, 2011).

3. Glick, B.R., & Patten C. (2022). Molecular Biotechnology: Principles and Applications. 6thedn. Washington, U.S.: ASM Press.

4. Snustad, D.P.,Simmons, M.J. (2019). Principles of Genetics, 7th edition. Chichester, England: John Wiley and Sons.

5. Brown, T. A. 2020. Gene Cloning & DNA Analysis: An Introduction. 8thedn. UK: Wiley Blackwell.

6. Primrose, S. B., Twyman, R. (2009). Principles of gene manipulation and genomics. Wiley. com.

7. Howe, C. J. (2007). Gene cloning and manipulation. Cambridge University Press.

8. S. B. Primrose, R. Twyman. (2006) Principles of Gene Manipulation and Genomics (Wiley-Blackwell, ed. 7).

9. H.M. Eun. (1996) Enzymology: Primer for Recombinant DNA Technology, Academic Press.

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Four Year Undergraduate Programme (Botany) Syllabus, Semester-VIII	
Session 2029-2030	
Part-A Introduction	
Subject	**Botany**
Semester	**VIII**
Name of the Course	Phytochemistry and Pharmacognosy
Course Code	**08/BOT/DSE/463T**
Course Type:	DSE
Level of the course (As per Annexure-I)	400-499
Advance Courses	
Course Learning Outcomes (CLO)	After completing the course: CLO1: Understand advanced methods for extraction, isolation, and structural characterization of phytochemicals. CLO2: Gain knowledge of quality control and standardization of herbal formulations based on WHO/ICH guidelines. CLO3: Learn about industrial aspects of herbal products, including nutraceuticals, cosmeceuticals, and novel drug delivery systems. CLO4: Apply in silico tools for phytochemical screening and prediction of ADME properties. CLO5: Develop skills to interpret and integrate phytochemical, industrial, and computational data for herbal product development
Credits	3+1=4
Total Marks	15+60=75 Theory and 5+20=25 Practical; Total Marks=100
Part-B Contents of the Course	
Total lecture per week	3Theory+2Practical=5hr

Units	**Topics**	**No. of Lecture/Contact Hours**
I	Definition, history, and scope: Crude drugs classification (morphological, chemical, pharmacological); Sources: Organized (roots, leaves) vs. unorganized (gums, resins) drugs from Indian flora; Cultivation factors: Soil, climate, plant hormones; polyploidy and mutation breeding for medicinal yield; Conservation: Medicinal Plant Conservation Areas, gene banks for Guggul and Amla.	9
II	Primary vs. secondary metabolites: Alkaloids, glycosides, flavonoids, tannins, terpenoids; Extraction methods: Maceration, percolation, Soxhlet, supercritical CO_2 extraction; Preliminary screening: Dragendorff's test (alkaloids), Borntrager's test (anthraquinones); Biosynthetic pathways: Shikimic acid, mevalonate for isoprenoids.	9
III	Alkaloids: Atropine (belladonna), morphine (opium), vinblastine (Catharanthus roseus); Glycosides: Digoxin (foxglove), sennosides (Cassia senna), salicin (willow bark); Flavonoids/Terpenoids: Quercetin, curcumin (Curcuma longa), guggulsterones (Commiphora); Volatile oils/Resins: Menthol (peppermint), podophyllotoxin, properties and therapeutic uses.	9
IV	Chromatographic techniques: TLC, HPLC, GC-MS for compound separation; Spectroscopic methods: UV-Vis, FTIR, NMR, mass	9

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	spectrometry for structure elucidation; Quantitative estimation: Spectrophotometry for total phenolics, alkaloids; Industrial production: Artemisinin from Artemisia annua, taxol from Taxus.	
V	Standardization: WHO guidelines, HPTLC fingerprinting, microbial limits; Adulteration detection: Microscopic, chemical tests for Ashwagandha substitutes; Regulatory aspects: AYUSH GMP, Schedule T, herbal formulations (churna, asava); Databases: NAPRALERT, Dr. Duke's Phytochem Database for Indian plants.	9

Laboratory exercise

Credits	Hours	Marks	Total Hr
1	**2**	**5+20=25**	**30**

1. Morphological identification of 10 crude drugs (*Tulsi*, *Neem*, *Giloy*).
2. Successive extraction and phytochemical screening of desert plants.
3. TLC profiling of flavonoids/alkaloids from local herbs.
4. Quantitative estimation: Total ash, acid insoluble ash, extractive values.
5. HPTLC analysis of marker compounds (simulation with available equipment).

Suggested Reading

1. Kokate, C. K. (2018). *Pharmacognosy* (16th ed.). Nirali Prakashan. ISBN: 978-9351649331. Publisher: Nirali Prakashan, Pune.
2. Trease, G. E., & Evans, W. C. (2009). *Trease and Evans Pharmacognosy* (16th ed.). Saunders Elsevier. ISBN: 978-1416029913. Publisher: Elsevier.
3. Harborne, J. B. (1998). *Phytochemical Methods: A Guide to Modern Techniques of Plant Analysis* (3rd ed.). Chapman & Hall. ISBN: 978-0412572703. Publisher: Springer.
4. Wagner, H., & Bladt, S. (1996). *Plant Drug Analysis: A Thin Layer Chromatography Atlas* (2nd ed.). Springer. ISBN: 978-3540586762. Publisher: Springer-Verlag.
5. Shah, B. N., & Seth, A. K. (2010). *Textbook of Pharmacognosy and Phytochemistry*. Elsevier. ISBN: 978-8131232606. Publisher: Elsevier, New Delhi.
6. Dutt, S., Kumar, R., & Kalia, P. (2025). *A Text Book of Pharmacognosy and Phytochemistry-I*. Bright Sky Publications. ISBN: 978-93-6233-161-8. Publisher: Bright Sky Publications.
7. Heinrich, M., Barnes, J., Gibbons, S., & Williamson, E. M. (2023). *Fundamentals of Pharmacognosy and Phytotherapy* (4th ed.). Elsevier. ISBN: 9780323834346. Publisher: Elsevier.
8. Rangari, V. D. (2018). *Pharmacognosy and Phytochemistry Part-I* (2nd ed.). Career Publications. ISBN: 978-81-88739-45-5. Publisher: Career Publications, Nashik.
9. Gupta, M. K. (2025). *Text Book of Pharmacognosy and Phytochemistry-II*. Shashwat Publication. ISBN: 978-93-6087-508-4. Publisher: Shashwat Publication.

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Four Year Undergraduate Programme (Botany) Syllabus, Semester-VIII	
Session 2029-2030	
Part-A Introduction	
Subject	**Botany**
Semester	**VIII**
Name of the Course	Traditional knowledge and IPR practices in plant science
Course Code	**08/BOT/DSE/464T**
Course Type:	DSE
Level of the course (As per Annexure-I)	400-499
Advance Courses	
Course Learning Outcomes (CLO)	After completing the course: CLO1: Understand the definition, types, and value of Traditional Knowledge in plant science. CLO2: Analyze the role of IPR in protecting traditional botanical knowledge and preventing biopiracy. CLO3: Study national and international legal frameworks (CBD, Nagoya Protocol, PPVFR Act) on biodiversity and access to genetic resources. CLO4: Learn methods to document and validate indigenous technical knowledge related to plants. CLO5: Develop skills to apply TK and IPR frameworks for ethical use of plant genetic resources in research and development.
Credits	3+1=4
Total Marks	15+60=75 Theory and 5+20=25 Practical; Total Marks=100
Part-B Contents of the Course	
Total lecture per week	3Theory+2Practical=5hr

Units	**Topics**	**No. of Lecture/Contact Hours**
I	Concept & Scope: Definition, transmission, and characteristics of TK; Tribal and folk knowledge systems; Ethnobotany & Plant Science: Role of traditional knowledge in medicine (Ayurveda, Unani, Siddha), agriculture, and forestry; Biodiversity & Indigenous Knowledge: Indigenous Ecological Knowledge (IEK) in conservation of biodiversity; Threats to TK: Erosion of traditional practices, modern encroachment, and misappropriation.	9
II	Biopiracy Case Studies: Historical cases of misappropriation—Neem Case, Turmeric Case, Ayahuasca Case; Documentation of TK: The role of the Traditional Knowledge Digital Library (TKDL) and Traditional Knowledge Resource Classification (TKRC) in preventing patents; Defensive Protection: Strategies to prevent third parties from obtaining illegitimate IPRs over TK.	9
III	Convention on Biological Diversity (CBD - 1992): Article 8(j) and conservation of biological diversity; Nagoya Protocol (2010): Access to Genetic Resources and Fair and Equitable Sharing of Benefits (ABS) arising from their utilization; WIPO Activities: Intergovernmental Committee on	9

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	Intellectual Property and Genetic Resources, Traditional Knowledge, and Folklore; UPOV Convention: Plant Breeder's Rights vs. Farmer's Privilege.	
IV	Biological Diversity Act, 2002: Structure, State Biodiversity Boards, and ABS mechanisms; Protection of Plant Varieties and Farmers' Rights (PPVFR) Act, 2001: Registration of plant varieties, Farmer's rights, and Breeder's rights; Geographical Indications (GI): Protection of plant-based products (e.g., Darjeeling Tea, Basmati); Patent Act, 1970 (Amended): Section 3(p) (non-patentability of TK) and disclosure of source.	9
V	Validation of Indigenous Technical Knowledge (ITK): Scientific validation of traditional agricultural and medicinal practices; Material Transfer Agreements (MTA): Legal requirements for sharing plant genetic materials; Ethical Practices: Prior Informed Consent (PIC) and community rights.	9

Laboratory exercise

Credits	Hours	Marks	Total Hr
1	**2**	**5+20=25**	**30**

1. Documentation of traditional plant uses through field survey/interviews.
2. Identification of medicinal plants used in local traditional practices.
3. Case study analysis on biopiracy and IPR issues.
4. Study of patent documents and IPR databases.
5. Preparation of herbarium of ethnobotanical plants.

Report on role of TK in sustainable resource management.

Suggested Reading

1. Shiva, V. (1997). *Biopiracy: The Plunder of Nature and Knowledge*. South End Press. ISBN: 978-0896085608. Publisher: South End Press, Boston.
2. Hansen, S. A., & VanFleet, J. (2003). *Traditional Knowledge and Intellectual Property: A Handbook for Traditional Knowledge Holders*. American Association for the Advancement of Science (AAAS). ISBN: 978-0871686905. Publisher: AAAS Science and Human Rights Program.
3. WIPO. (2007). *Intellectual Property and Traditional Knowledge: Booklet No. 2*. World Intellectual Property Organization. ISBN: 978-92-805-1632-4. Publisher: WIPO, Geneva.
4. Mgbeoji, I. (2006). *Global Biopiracy: Patents, Plants, and Indigenous Knowledge*. Cornell University Press. ISBN: 978-0801444660. Publisher: Cornell University Press.
5. Robinson, D. F. (2010). *Confronting Biopiracy: Challenges, Cases and International Debates*. Earthscan. ISBN: 978-1844079993. Publisher: Routledge.
6. Dutfield, G. (2004). *Intellectual Property, Biogenetic Resources and Traditional Knowledge*. Earthscan. ISBN: 978-1844071331. Publisher: Earthscan Publications.
7. Binion, G. (Ed.). (2023). *Intellectual Property Rights and the Protection of Traditional Knowledge*. Bentham Science Publishers. ISBN: 978-9815274561. Publisher: Bentham Science Publishers.
8. Kuruk, P. (2010). *Protecting Traditional Knowledge: Issues, Challenges and Opportunities in a Globalizing World*. Routledge. ISBN: 978-1409402040. Publisher: Routledge.
9. Posey, D. A., & Dutfield, G. (1996). *Beyond Intellectual Property: Toward Traditional Resource Rights for Indigenous Peoples and Local Communities*. IDRC. ISBN: 978-0889368835. Publisher: International Development Research Centre.

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Four Year Undergraduate Programme (Botany) Syllabus, Semester-VIII	
Session 2029-2030	
Part-A Introduction	
Subject	**Botany**
Semester	**VIII**
Name of the Course	Biodiversity and Conservation Biology
Course Code	**08/BOT/DSE/465T**
Course Type:	DSE
Level of the course (As per Annexure-I)	400-499
Advance Courses	
Course Learning Outcomes (CLO)	After completing the course: CLO1: Understand levels, distribution and values of biodiversity CLO2: Identify major threats and causes of biodiversity loss CLO3: Explain conservation methods and role of communities CLO4: Understand invasive species and their impacts CLO5: Interpret biodiversity policies, ecosystem services and indices
Credits	3+1=4
Total Marks	15+60=75 Theory and 5+20=25 Practical; Total Marks=100
Part-B Contents of the Course	
Total lecture per week	3Theory+2Practical=5hr

Units	**Topics**	**No. of Lecture/Contact Hours**
I	Biodiversity – Concept and Importance: Definition, concept, scope and importance of biodiversity. Levels of biodiversity: genetic, species and ecosystem diversity. Values of biodiversity: ecological, economic, ethical, aesthetic and social values. India as a mega-diversity nation; phytogeographic zones and biodiversity richness of India. Basic concept of agrobiodiversity and cultivated plant diversity.	9
II	Biodiversity Loss and Management: Causes of biodiversity loss: habitat destruction, overexploitation, pollution, climate change, invasive species and urbanization. Loss of genetic, species and ecosystem diversity. Introduction to IUCN Red List, Red Data Book and threatened categories. Organizations involved in biodiversity management: IUCN, UNEP, UNESCO, WWF, NBPGR. Biodiversity legislation, communication and information management.	9
III	Conservation and Indian Biodiversity: Conservation of biodiversity: *in-situ* and *ex-situ* methods, protected areas, botanical gardens, seed banks and community conservation. India as a mega-biodiversity nation, biodiversity hotspots of India, Northeastern region, Western Ghats and Himalaya. Endemism in Indian flora and fauna. Sustainable development and biodiversity conservation.	9
IV	Biodiversity Resources and Biological Invasions: Role of plants in human welfare: forestry, avenue trees, ornamental plants, fruits, nuts, wood and beverages.	9

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	Concept of exotic and invasive species; natural and human-induced invasions. Ecological and economic impacts of invasives on ecosystems and communities : *Prosopis juliflora, Lantana camara, Parthenium hysterophorus.*	
V	Ecosystem Services, Policies and Biodiversity Indices: Biodiversity and ecosystem services: provisioning, regulating, supporting and cultural services. Government initiatives: National Biodiversity Action Plan, Green India Mission, Green Credit Programme, MISHTI Initiative and Amrit Dharohar. Measurement of biodiversity using Shannon–Wiener Index and Simpson Index. Introduction to biodiversity databases and digital mapping tools.	9

Laboratory exercise

Credits	Hours	Marks	Total Hr
1	**2**	**5+20=25**	**30**

1. Practical Course in Biodiversity and Conservation Biology
2. Quadrat-based plant diversity analysis in the university campus/local field and calculate species richness, Shannon–Wiener and Simpson indices.
3. Prepare a biodiversity map of the campus/local area showing trees, shrubs, herbs, birds or insects using field observation and simple GIS
4. Identify endemic, rare, endangered and threatened (RET) plant species of Rajasthan/India using herbarium sheets, photographs and online databases.
5. To survey invasive species in local habitats and prepare an impact note on species such as *Prosopis juliflora, Lantana camara or Parthenium hysterophorus.*
6. To prepare a case study on ecosystem services provided by a local pond, park, grassland, agricultural field or sacred grove.
7. To document agrobiodiversity of a local farm/village including crops, varieties and traditional practices.
8. To prepare a hotspot map of India and mark Western Ghats, Himalaya, Indo-Burma and Sundaland regions with key species examples.
9. To assess anthropogenic disturbance in a local ecosystem and record its impact on biodiversity.
10. To prepare a mini conservation action plan for campus biodiversity, sacred grove, wetland or village ecosystem.

Suggested Reading

1. Primack, R. B. (2020). Essentials of conservation biology (7th ed.). Sinauer Associates.
2. Gaston, K. J., & Spicer, J. I. (2013). Biodiversity: An introduction (2nd ed.). Wiley-Blackwell.
3. Hunter, M. L., Gibbs, J. P., & Sterling, E. J. (2017). Fundamentals of conservation biology (3rd ed.). Wiley.
4. Sodhi, N. S., Gibson, L., & Raven, P. H. (Eds.). (2013). Conservation biology: Voices from the tropics. Wiley-Blackwell.
5. Krishnamurthy, K. V. (2004). An advanced textbook on biodiversity: Principles and practice. Oxford & IBH.
6. Singh, J. S., Singh, S. P., & Gupta, S. R. (2017). Ecology, environmental science and conservation. S. Chand.
7. Wickens, G. E. (2021). Economic botany: Principles and practices. Springer.
8. Martin, L. J. (2022). Wild by design: The rise of ecological restoration. Harvard University Press.
9. Thorogood, C. (2024). Pathless forest: The quest to save the world's largest flowers. Penguin Press.
10. Springer. (2021). Wildlife biodiversity conservation: Challenges and applications. Springer.
11. Websites: Convention on Biological Diversity (CBD): https://www.cbd.int (Global biodiversity policies, targets and frameworks)
12. Global Biodiversity Information Facility (GBIF):https://www.gbif.org (Species occurrence and biodiversity data)
13. IUCN Red List: https://www.iucnredlist.org (Threatened species and conservation status)
14. National Biodiversity Authority (India):https://nbaindia.org
15. India Biodiversity Portal:https://indiabiodiversity.org
16. Plants of the World Online (Kew); https://powo.science.kew.org

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Four Year Undergraduate Programme (Botany) Syllabus, Semester-VIII	
Session 2029-2030	
Part-A Introduction	
Subject	**Botany**
Semester	**VIII**
Name of the Course	Plant Diseases and their Management
Course Code	**08/BOT/DSE/466T F**
Course Type:	DSE
Level of the course (As per Annexure-I)	400-499
Advance Courses	
Course Learning Outcomes (CLO)	After completing the course: CLO1: Learn about the biology of plant pathogens, including life cycles, infection mechanisms, and methods of spread. CLO2: Learn the principles and methods of plant disease management, including cultural, chemical, biological, and genetic approaches. CLO3: Learn the principles and techniques of plant disease diagnosis, including symptom observation, pathogen isolation, and molecular methods. CLO4: Develop skills in critically evaluating scientific literature on plant disease management and interpreting research findings. CLO5: Develop skills in applying diagnostic and management strategies to real-world plant disease problems.
Credits	3+1=4
Total Marks	15+60=75 Theory and 5+20=25 Practical; Total Marks=100
Part-B Contents of the Course	
Total lecture per week	3Theory+2Practical=5hr

Units	**Topics**	**No. of Lecture/Contact Hours**
I	Non- infectious disease: mineral deficiencies, Black heart of Potato and Khaira disease of Rice. Viroid and Viral disease: Potato spindle tuber, Tobacco Mosaic, Yellow vein mosaic of Bhindi, Leaf curl of Papaya, yellow mosaic of beans Phytoplasma disease: Little leaf of Brinjal, Witches broom of potato, sesamum phyllody, grassy shoot of sugarcane	9
II	Bacterial disease: Major plant pathogenic bacteria, pathogenic bacteria-host interaction, Citrus canker, Angular leaf spot of cotton, Tundu disease of wheat, Bacterial wilt of Cucurbit & tomato and Crown gall of fruits plants.	9
III	Fungal disease: Wart disease of potato, Damping off of chilli, Late blight of potato, Downy mildew & Green ear disease of bajra, stem gall of coriander and Powdery mildew of cereals.	9
IV	Fungal disease: Ergot of Bajra, Smut of Bajra, Rust of Wheat, Early blight of Potato, Tikka disease of Groundnut, Blast of Rice, Red rot of Sugarcane, Wilt of cotton and Blight of Gram.	9
V	Nematode disease: General characters of plant parasitic nematodes, host parasite interactions, Principles and methods of nematode control, Ear cockle of Wheat, Molya disease of Barley and Root Knot disease of vegetables.	9

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Laboratory exercise

Credits	Hours	Marks	Total Hr
1	2	5+20=25	30

1. Demonstration of Koch's postulates for pathogenic microbes.
2. Isolation and Purification of plant pathogenic viruses.
3. Detection of plant viruses from infected leaf using ELISA and Western Blot.
4. Isolation of male, female, II stage larva and eggs of Nematode for disease cycle study.
5. Microscopic study of pathogenic fungi: Synchtrium, Albugo, Sclerospora, Pythium, Phytopthora, Sclerospora, Erysphae, Alternaria, Curvularia, Helminthosporium, Drechslera, Fusarium and Colletotrichum.
6. Microscopic study of pathogenic bacteria: Agrobacterium, Xanthomonas and Pseudomonas.
7. Microscopic study of biocontrol agents: Trichoderma, Gliocladium, Metarrhizium, Paeciliomyces, Beavaria, Streptomyces and Bacillus thuringiensis.
8. In vitro study of effect of different fungicide on growth of pathogenic microbes.
9. In vitro study of effect of different biocide on growth of pathogenic microbes.
10. Antagonistic effect of biocontrol agents on pathogenic microbes.
11. Isolation of genomic DNA from pathogenic fungi and bacteria Qualitative and quantitative analysis of genomic DNA using gel electrophoresis and UV- spectrophotometer.
12. Amplification of ITS-5.8S gene of pathogenic fungi using PCR
13. Amplification of 16S gene of pathogenic bacteria using PCR
14. Blast searching of amplified gene sequences for identification of pathogens

Suggested Reading

1. Agarwal, V.K. and Sissclair, J.B. 1993. Principles of Seed Pathology. Vol. I & II CBS Publishers and Distributors, India
2. Agrios, G.N. 1997. Plant Pathology. Academic Press, London.
3. Albajes, R., Gullino, M.L., Van Lenteren, J.C. and Elad, Y. 2000. Integrated Pest and Disease management in Greenhouse Crops. Kiuwel Academic Publishers.
4. Mehrotra, R.S. 1993. Plant Pathology, Tata McGraw Hill.
5. Neergaard, P. 1997. Seed pathology, Vol. I & II. The Macmillan Press.Ltd, London.
6. Pandey, B.P. 1997. Plant Pathology, Pathogen and Plant Disease. S. Chand and Company Ltd.
7. Rangaswamy, G. and Mahadevan, A. 1999. Disease of crop plants in India. Prentice Hall of India, New Delhi.
8. Roger, H. 2001. Mathew‟s Plant Virology, Academic Press, NY.
9. Sharma, P.D. 2006. Plant Pathology. Rastogi Publications, India
10. Singh, R.S. 1998. Plant disease. Oxford and IBH Publication Co. Pvt. Ltd.
11. Singh, R.S. 2005. Introduction to Principles of Plant Pathology. Oxford & IBH Publication Co. Pvt. Ltd.
12. Strange, R.N. 2003. Plant resistance mechanism (SAR, ISR) –Introduction to plant Pathology, John Wiley & Sons, USA.
13. Suryanarayana, D. 1978. Seed pathology. Vikas Publishing House, Pvt. Ltd.

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Four Year Undergraduate Programme (Botany) Syllabus, Semester-VIII		
Session 2029-2030		
Part-A Introduction		
Subject	**Botany**	
Semester	**VIII**	
Name of the Course	Industrial Botany	
Course Code	**08/BOT/DSE/471T**	
Course Type:	DSE	
Level of the course (As per Annexure-I)	400-499	
Advance Courses		
Course Learning Outcomes (CLO)	After completing the course: CLO1: Understand major industrial crops, their cultivation practices, and associated value chains. CLO2: Gain knowledge of primary and secondary processing techniques for plant-based products. CLO3: Learn about bio-based industries such as biofuels, nutraceuticals, biopolymers, biofertilizers, biopesticides, and enzymes. CLO4: Understand regulatory frameworks, quality standards, and commercial aspects of plant-based industries, including paper and rubber. CLO5: Develop skills in analyzing the economic and industrial applications of plant-based products and processes.	
Credits	3+1=4	
Total Marks	15+60=75 Theory and 5+20=25 Practical; Total Marks=100	
Part-B Contents of the Course		
Total lecture per week	3Theory+2Practical=5hr	

Units	**Topics**	**No. of Lecture/Contact Hours**
I	Major industrial crops: Essential oil plants (*Eucalyptus*, *Mentha*), oleoresins (*Capsicum*), natural dyes (*Indigofera*); Value chain analysis: From cultivation to market (seed to shelf); Rajasthan specifics: *Isabgol* (Psyllium husk), *Henna* (Lawsonia), *Aloe vera* gel processing; Value chain analysis: Seed-to-shelf; yield optimization via high-density planting, drip irrigation, varietal selection; Paper industry crops: Bamboo, bagasse, eucalyptus, and kenaf; Rubber industry: Hevea rubber cultivation, latex extraction, plantation management.	9
II	Primary processing: Steam distillation, solvent extraction, cold pressing for oils; Secondary metabolites recovery: Supercritical CO_2, enzymatic extraction; Fermentation industries: Mushroom spawn production, single-cell protein from algae; Waste valorization: Pectin from citrus waste, biogas from spent plant material.	9
III	First/second generation biofuels: *Jatropha biodiesel, Pongamia pinnata*; Biopolymers: Starch (tapioca), cellulose (cotton linter), natural rubber (Hevea); Nutraceuticals: Fenugreek galactomannans, Guggul sterols extraction; Green chemistry: Plant-based surfactants, natural preservatives.	9
IV	Plant cell culture for secondary metabolites: *Taxus taxol, Artemisia artemisinin*; Biofertilizers: *Rhizobium*, *Azotobacter*, VAM production	9

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	protocols; Biopesticides: Neem azadirachtin, karanjin from Pongamia; Enzyme industries: Amylase from *Aspergillus*, *pectinase* for fruit juice clarification.	
V	Standards: FSSAI, AGMARK, ISO 22000 for botanical extracts; Regulatory compliance: NPPO phytosanitary certificates, export documentation; Business models: Contract farming, PPP for medicinal plant clusters; Case studies: Indian vanilla revolution, sandalwood oil industry revival, rubber and paper industry case studies.	9

Laboratory exercise

Credits	Hours	Marks	Total Hr
1	**2**	**5+20=25**	**30**

1. Identification of Industrial Crops – Eucalyptus, Mentha, Capsicum, Indigofera, Aloe vera, Isabgol, Henna, Bamboo, Jatropha, Hevea.
2. Essential Oil Extraction – Steam distillation of Mentha/Eucalyptus leaves; oil yield estimation.
3. Oleoresin & Dye Extraction – Solvent extraction of Capsicum oleoresin; natural dyes from Indigofera/Henna.
4. Paper Industry – Pulp preparation from Bamboo/Bagasse; sheet formation and quality comparison.
5. Rubber Industry – Collection of Hevea latex; preparation of crude rubber sheets.
6. Secondary Metabolite Recovery – Extraction of Aloe vera gel; estimation of bioactive compounds.
7. Fermentation Industries – Mushroom spawn preparation; cultivation of single-cell protein from algae.
8. Waste Valorization – Pectin extraction from citrus peel; biogas production from plant residues.
9. Biofertilizers & Biopesticides – Isolation/culture of Rhizobium/Azotobacter; Neem leaf extract preparation.
10. Quality & Yield Analysis – Quantitative analysis of essential oils, oleoresins, latex; comparison of extraction methods.

Suggested Reading

1. Kochhar, S. L. (2016). *Economic Botany*. Cambridge University Press. ISBN: 978-1107112940. Publisher: Cambridge University Press India.
2. Prakash, A., & Rao, J. (2012). *Industrial Botany*. Agrobios (India). ISBN: 978-8190597917. Publisher: Agrobios International, Jodhpur.
3. Dhumal, K. N. (2020). *Fundamentals of Botany: Plant Diversity and Industrial Botany*. Nirali Prakashan. ISBN: 978-9388708569. Publisher: Nirali Prakashan, Pune.
4. Sharma, O. P. (2022). *Economic Botany of Crop Plants*. Scientific Publishers. ISBN: 9789386595591. Publisher: Scientific Publishers, Jodhpur.
5. Pullaiah, T. (2016). *Industrial Botany: Economic and Medicinal Plants*. Regency Publications. ISBN: 9788121542803. Publisher: Regency Publications, New Delhi.
6. Davis, Z. (2018). *Economic Botany of Angiosperms*. Agri Horti Press. ISBN: 9789387642621. Publisher: Agri Horti Press, New Delhi.
7. Maiti, R. K. (2023). *An Introduction to Modern Economic Botany*. Agrobios International. ISBN: 9788177542141. Publisher: Agrobios International, Jodhpur.
8. Sharp Publications. (2015). *Industrial Botany Paper II (I & II)*. Sharp Publications. ISBN: 978-9382117952. Publisher: Sharp Publications, Pune.
9. Baruah, A. (2019). *A Textbook of Economic Botany*. B.H. College Publications. ISBN: 9788194134792. Publisher: B.H. College, Howly.

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Four Year Undergraduate Programme (Botany) Syllabus, Semester-VIII	
Session 2029-2030	
Part-A Introduction	
Subject	**Botany**
Semester	**VIII**
Name of the Course	Aquatic Botany
Course Code	**08/BOT/DSE/472T**
Course Type:	DSE
Level of the course (As per Annexure-I)	400-499
Advance Courses	
Course Learning Outcomes (CLO)	After completing the course: CLO1: Understand the diversity, ecology, and taxonomy of aquatic plants. CLO2: Analyze physical, chemical, and biological parameters of aquatic ecosystems. CLO3: Gain knowledge of the adaptations, productivity, and ecological roles of freshwater and marine plants. CLO4: Apply principles of conservation and management of aquatic habitats. CLO5: Develop skills for research, monitoring, and sustainable utilization of aquatic plant resources.
Credits	3+1=4
Total Marks	15+60=75 Theory and 5+20=25 Practical; Total Marks=100
Part-B Contents of the Course	
Total lecture per week	3Theory+2Practical=5hr

Units	**Topics**	**No. of Lecture/Contact Hours**
I	Introduction to Aquatic Botany: Definition, scope, and importance of aquatic botany; Classification of aquatic plants: Hydrophytes, Macrophytes, Bryophytes, Algae; Structure, morphology, and adaptations of aquatic plants (submerged, floating, emergent); Life cycles and reproductive adaptations in aquatic plants.	9
II	Aquatic Ecosystems: Types of aquatic ecosystems: Lentic, Lotic, Wetlands, Estuaries, Mangroves; Physico-chemical properties of water: Temperature, pH, dissolved oxygen, nutrients; Biotic components: Phytoplankton, macrophytes, periphyton, and their ecological roles; Productivity and energy flow in aquatic ecosystems.	9
III	Freshwater Algae and Macrophytes: Diversity of freshwater algae (Chlorophyta, Cyanophyta, Bacillariophyta); Ecological importance of algae in nutrient cycling and oxygen production; Macrophytes: Classification, morphology, and ecological functions; Role in food webs, water purification, and habitat formation.	9
IV	Marine and Wetland Plants: Marine algae: Chlorophyta, Phaeophyta, Rhodophyta; their economic and ecological importance; Mangroves: Adaptations, zonation, and ecological roles; Wetland plants: Adaptations,	9

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	productivity, and biodiversity significance; Threats to aquatic habitats: Pollution, invasive species, climate change.	
V	Conservation and Utilization of Aquatic Plants: Importance of aquatic plants in human welfare: food, medicine, biofuel, and ornamentals; Conservation strategies: In-situ (lakes, wetlands, mangroves) and ex-situ (aquatic botanical gardens); Aquatic plant management for sustainable fisheries, water purification, and ecosystem restoration; Case studies of threatened aquatic ecosystems and restoration projects.	9

Laboratory exercise

Credits	Hours	Marks	Total Hr
1	**2**	**5+20=25**	**30**

1. Identification of common aquatic plants (freshwater, wetland, and marine).
2. Study of morphological adaptations in submerged, floating, and emergent plants.
3. Collection and microscopic study of phytoplankton and periphyton.
4. Measurement of water parameters: pH, dissolved oxygen, temperature, turbidity, and nutrients.
5. Assessment of aquatic plant biomass and productivity.
6. Mapping and survey of local aquatic habitats and their plant diversity.
7. Preservation and mounting of aquatic plant specimens.
8. Study of invasive aquatic species and their impact on native flora.
9. Preparation of herbarium sheets of wetland and mangrove plants.

Field visit to a wetland, lake, or mangrove ecosystem for ecological observation.

Suggested Reading

1. Ervin, G. N. (2024). *The Biology of Aquatic and Wetland Plants* (1st ed.). ISBN: 9781032465395. Publisher: Routledge / CRC Press.
2. Sculthorpe, C. D. (2019). *The Biology of Aquatic Vascular Plants* (Reprint ed.). ISBN: 9780367261307. Publisher: Routledge.
3. Wetzel, R. G. (2001). *Limnology: Lake and River Ecosystems* (3rd ed.). ISBN: 978-0127448706. Publisher: Academic Press.
4. Barret, S. C. H., & Strother, J. L. (Eds.). (2022). *Aquatic Angiosperm Biology* (2nd ed.). ISBN: 9789402413771. Publisher: Springer.
5. Chambers, P. A., & Kalff, J. (2020). *Macrophyte Ecology: Methods and Applications*. ISBN: 9780198574696. Publisher: Oxford University Press.
6. Sand-Jensen, K., & Riis, T. (Eds.). (2023). *Aquatic Plants in Nordic Lakes and Rivers*. ISBN: 9788770030571. Publisher: Aarhus University Press.
7. Reddy, K. R., & DeBusk, W. F. (2018). *Aquatic Plants for Water Treatment and Resource Recovery*. ISBN: 9781931959789. Publisher: Magnolia Publishing.
8. Pieterse, A. H., & Murphy, K. J. (Eds.). (2019). *Aquatic Weeds: The Ecology and Management of Nuisance Aquatic Vegetation*. ISBN: 9780198541395. Publisher: Oxford University Press.
9. Larkum, A. W. D., Orth, R. J., & Duarte, C. M. (Eds.). (2022). *Seagrasses: Biology, Ecology and Conservation* (2nd ed.). ISBN: 9789402405200. Publisher: Springer.
10. Bowmer, K. H., & Mitchell, D. S. (Eds.). (2021). *Aquatic Weed Management*. ISBN: 9780367261307. Publisher: CRC Press / Routledge.
11. Gopal, B. (2017). *Aquatic Plant Studies*. ISBN: 9788177542141. Publisher: Agrobios International.
12. van der Velde, G., Rajagopal, S., & Lecheler, F. (Eds.). (2023). *Aquatic Macrophytes: Ecology, Functioning and Management*. ISBN: 9783030854626. Publisher: Springer.
13. Pokorny, J., & Hauser, V. (2024). *Aquatic Plants and Their Control*. ISBN: 9781789242071. Publisher: CABI Publishing.

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Four Year Undergraduate Programme (Botany) Syllabus, Semester-VIII	
Session 2029-2030	
Part-A Introduction	
Subject	**Botany**
Semester	**VIII**
Name of the Course	Advances in Mycology
Course Code	**08/BOT/DSE/473T**
Course Type:	DSE
Level of the course (As per Annexure-I)	400-499
Advance Courses	
Course Learning Outcomes (CLO)	After completing the course: CLO1: Analyze recent taxonomic revisions and the role of genomic tools in fungal classification. CLO2: Understand molecular mechanisms of fungal pathogenesis and symbiotic interactions. CLO3: Evaluate biotechnological applications of fungi in industry and medicine. CLO4: Apply advanced techniques for fungal identification and strain improvement. CLO5: Develop skills in interpreting and integrating genomic, ecological, and industrial data for applied mycology.
Credits	3+1=4
Total Marks	15+60=75 Theory and 5+20=25 Practical; Total Marks=100
Part-B Contents of the Course	
Total lecture per week	3Theory+2Practical=5hr

Units	**Topics**	**No. of Lecture/Contact Hours**
I	Fungal Systematics and Phylogeny: Modern fungal classification: Molecular phylogeny, DNA barcoding; Advances in Ascomycota, Basidiomycota, Chytridiomycota systematics; Fungal genomics and evolutionary insights; Cryptic species, species complexes, and their identification using molecular markers.	9
II	Fungal Ecology and Interactions: Fungal biodiversity in terrestrial, aquatic, and extreme environments; Mycorrhizal associations: Ectomycorrhiza, Endomycorrhiza, and orchid mycorrhiza; Fungal interactions: Symbiosis, endophytes, pathogens, and epiphytic fungi; Fungal role in nutrient cycling, decomposition, and ecosystem functioning.	9
III	Industrial and Biotechnological Mycology: Fungi in food, pharmaceutical, and enzyme industries; Production of antibiotics, organic acids, pigments, and bioactive metabolites; Fermentation technologies: Submerged and solid-state fermentation; Advances in fungal secondary metabolite engineering and metabolic pathway optimization.	9

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IV	Fungal Genetics, Molecular Biology, and Pathogenesis: Genetic engineering and genome editing in fungi (CRISPR, RNAi); Fungal genomics, transcriptomics, proteomics, and metabolomics applications; Molecular basis of fungal pathogenicity and virulence; Fungal stress response mechanisms and adaptation strategies.	9
V	Environmental and Applied Mycology: Fungi in bioremediation: Heavy metals, oil spills, xenobiotic degradation; Mycofiltration, mycoremediation, and myco-augmentation approaches; Fungal biodiversity conservation and sustainable utilization; Emerging areas: Myconanotechnology, fungal biomaterials, and industrial applications of extremophilic fungi.	9

Laboratory exercise

Credits	Hours	Marks	Total Hr
1	2	5+20=25	30

1. Isolation and pure culture of fungi from soil, water, and plant materials.
2. Study of fungal morphology: Hyphae, spores, and fruiting bodies (light microscopy).
3. Identification of fungi using macroscopic and microscopic characters.
4. Staining techniques for fungal structures (lactophenol cotton blue, calcofluor).
5. Measurement of fungal growth under different environmental conditions (pH, temperature, light).
6. Screening of fungi for enzyme production (amylase, cellulase, protease).
7. Qualitative and quantitative estimation of fungal secondary metabolites (pigments, organic acids).
8. Study of fungal-plant interactions: Mycorrhizal colonization in roots.
9. Fungal pathogenicity assay on model plants or plant tissues.
10. Molecular identification of fungi using ITS-PCR or DNA barcoding.
11. Bioremediation potential: Degradation of dyes, oils, or heavy metals by selected fungi.
12. Solid-state and submerged fermentation experiments for biomass or metabolite production.

Suggested Reading

1. Deshmukh, S. K., Sridhar, K. R., & El Enshasy, H. A. (2025). *Bioprospects of Macrofungi: Recent Developments* (1st ed.). ISBN: 9781032865117. Publisher: CRC Press / Routledge.
2. Singh, S., & Sharma, R. (2024). *Fungal Biotechnology: Industrial Applications and Market Potential* (1st ed.). ISBN: 9780443132636. Publisher: Elsevier.
3. Sridhar, K. R., & Deshmukh, S. K. (2025). *Ecology of Macrofungi: An Overview* (1st ed.). ISBN: 9781032499271. Publisher: CRC Press.
4. Sridhar, K. R., Deshmukh, S. K., Fung, S. Y., & Mahadevakumar, S. (2024). *Advances in Cordyceps Research: Prospects and Avenues* (1st ed.). ISBN: 9781032555717. Publisher: CRC Press.
5. Kharte, S. (2023). *Advanced Mycology and Plant Pathology*. ISBN: 9788119843942. Publisher: Academic Guru Publishing House.
6. Heitman, J., Howlett, B. J., Crous, P. W., Stukenbrock, E. H., & Xu, J. (Eds.). (2023). *The Fungal Kingdom* (2nd ed.). ISBN: 9781683670581. Publisher: ASM Press.
7. Hyde, K. D., & Xu, J. (Eds.). (2025). *Mycosphere Notes 521–571: Fungal Biodiversity Special Edition*. ISBN: 9781914943002. Publisher: Mycosphere Press.
8. Farid Preet, A. (2025). *Fungal Biotechnology: Advancements in Drug Discovery, Healthcare and Environmental Solutions* (1st ed.). ISBN: 9781032736497. Publisher: CRC Press.
9. Deshmukh, S. K., & Sridhar, K. R. (2024). *Progress in Mycological Research: Macrofungi Ecology* (Vol. 1). ISBN: 9781032499271. Publisher: Routledge.
10. Read, N. D. (2023). *Fungal Morphogenesis* (2nd ed.). ISBN: 9781032406145. Publisher: CRC Press.
11. Martin, F., Uroz, S., & Hibbett, D. S. (Eds.). (2024). *Fungal Genomics: Methods and Protocols* (3rd ed.). ISBN: 9781071639595. Publisher: Humana / Springer.
12. Townsend, J. P., & Wilke, C. O. (2023). *Evolutionary Mycology*. ISBN: 9780192895816. Publisher: Oxford University Press.
13. Hyde, K. D., & Zhou, L. (2024). *Fungal Diversity in China: Microfungi and Macrofungi* (Vol. 16). ISBN: 9789819992254. Publisher: Springer.

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Four Year Undergraduate Programme (Botany) Syllabus, Semester-VIII	
Session 2029-2030	
Part-A Introduction	
Subject	**Botany**
Semester	**VIII**
Name of the Course	Botanical Entrepreneurship
Course Code	**08/BOT/DSE/474T**
Course Type:	DSE
Level of the course (As per Annexure-I)	400-499
Advance Courses	
Course Learning Outcomes (CLO)	After completing the course: CLO1: Understand the principles, traits, and types of entrepreneurship in the botanical and bio-based sectors. CLO2: Learn methods for producing and adding value to plant-based products, including mushrooms, fruits, vegetables, and secondary metabolites. CLO3: Develop practical skills in bio-enterprises, including nursery management, floriculture, spirulina farming, and biopesticides/biofertilizers. CLO4: Gain knowledge of organizational and governmental support systems, funding, and regulatory frameworks for botanical entrepreneurship. CLO5: Analyze case studies and develop innovative strategies for self-employment and start-ups in the plant-based industries.
Credits	3+1=4
Total Marks	15+60=75 Theory and 5+20=25 Practical; Total Marks=100
Part-B Contents of the Course	
Total lecture per week	3Theory+2Practical=5hr

Units	**Topics**	**No. of Lecture/Contact Hours**
I	Fundamentals of Entrepreneurship: Entrepreneurial traits: Motivation, resilience, risk-taking, innovation, and barriers; Types of business organization: Sole proprietorship, partnership, corporation, and limited liability companies; Communication skills: Personal selling, negotiation, and persuasive communication; Introduction to bio-entrepreneurship: Definition, scope, opportunities in plant-based industries.	9
II	Value Addition and Processing of Plant Products: Mushroom cultivation: Mushroom house construction, sterilization, spawn production, cultivation of oyster and paddy straw mushrooms, preservation, and value-added products; Fruit processing: Jams, jellies, fruit slices, dehydration, candy making, freezing; Vegetable processing: Flakes/chips (potato, onion), garlic powder, frozen vegetables; Preservation techniques: Spoilage causes, microbial control, drying, pasteurization, sterilization, canning, low-temperature storage, chemical preservatives.	9

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III	Bio-Ventures and Innovative Plant-Based Enterprises: Spirulina farming: Industrial culturing and applications; Aromatic and medicinal plants: Essential oils, extraction techniques, utilization in industry; Botanicals in cosmetics: Skin and hair care product development, quality control, dosage standardization; Plant nurseries: Cultivation for self-employment; Floriculture: Cultivation of Anthurium, Orchids, Jasmine; challenges and prospects; Seaweed fertilizers: Extraction, products, applications, benefits, and limitations; Biopesticides and biofertilizers: Sources, production methods, applications, and benefits; Botanical specimen preparation: Collection, preservation, slide preparation, labeling, and marketing.	9
IV	Organizational and Governmental Support: Entrepreneurship development programs: MSME, DBT, BIRAC, Startups, Make in India initiatives; Financial support and resource mobilization: SIDCO, Micro, Small, and Medium Enterprises, Mudra Yojana, Pradhan Mantri Rozgar Yojana, Udyogini Scheme; Women entrepreneurship support: MAHIA, Shakti Scheme, Women Entrepreneurs India Scheme, SHGs, NABARD, MICROSTAT, Khadi and Village Industries Commission; Regulatory frameworks: FDA, EU, DSIR, AYUSH, FSSAI, and compliance requirements for bio-businesses.	9
V	Case Studies, Innovation, and Business Planning: Biographical analysis of successful bio-entrepreneurs; Value chain analysis of plant-based industries: Seed to shelf; Development of business models for plant-based products: Contract farming, PPP initiatives; Innovation, problem-solving, and strategies for sustainable bio-enterprises.	9

Laboratory exercise

Credits	Hours	Marks	Total Hr
1	**2**	**5+20=25**	**30**

1. Market survey of plant-based products.
2. Prepare a simple business plan.
3. Mushroom cultivation (oyster/paddy straw).
4. Nursery propagation of plants (seed/vegetative).
5. Fruit and vegetable processing (jams, pickles, dehydrated products).
6. Extraction of essential oils and medicinal compounds.
7. Biofertilizer production (Rhizobium, Azotobacter).
8. Biopesticide formulation (Neem, Karanj).
9. Floriculture practice and garden design.
10. Spirulina cultivation and processing.
11. Preparation of botanical specimens and slides.
12. Case study presentation on successful bio-entrepreneurs.

Suggested Reading

1. Desai, V. (2015). *Entrepreneurship Development* (1st ed.). Himalaya Publishing House. ISBN: 978-9350246131. Publisher: Himalaya Publishing House, Mumbai.
2. Khanna, S. S. (2016). *Entrepreneurly Development*. S. Chand Publishing. ISBN: 978-8121925122. Publisher: S. Chand & Company Ltd., New Delhi.
3. Manohar, D. (1989). *Entrepreneurship of Small Scale Industries* (Vol. III). Deep & Deep Publications. ISBN: 978-8171002003. Publisher: Deep & Deep Publications Pvt. Ltd., New Delhi.
4. Lal, G., Siddappa, G. S., & Tandon, G. L. (1988). *Preservation of Fruits and Vegetables*. Indian Council of Agricultural Research (ICAR). Publisher: ICAR Publications, New Delhi.

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5. Ranganna, S. (2001). *Handbook of Analysis and Quality Control for Fruit and Vegetable Products* (2nd ed.). Tata McGraw-Hill. ISBN: 978-0074518519. Publisher: Tata McGraw-Hill Publishing Company Ltd., New Delhi.
6. Cruse, W. V., & Fellows, P. J. (2000). *Commercial Fruit and Vegetable Processing*. CRC Press. ISBN: 978-0834212657. Publisher: CRC Press, Boca Raton, USA.
7. Desai, V. (2005). *Dynamics of Entrepreneurial Development and Management*. Himalaya Publishing House. ISBN: 978-8183185090. Publisher: Himalaya Publishing House, Mumbai.
8. Prasanna Chandra. (2020). *Projects: Planning, Analysis, Selection, Financing, Implementation and Review* (10th ed.). McGraw Hill Education. ISBN: 978-9355323088. Publisher: McGraw Hill Education, New Delhi.
9. Khanka, S. S. (2006). *Entrepreneurial Development*. S. Chand & Co. ISBN: 978-8121919410. Publisher: S. Chand Publishing, New Delhi.
10. Pathak, V. N., Yadav, N., & Maneesha. (2000). *Gaur Mushroom Production and Processing Technology*. Vedams eBooks Pvt. Ltd. ISBN: 978-8171711001. Publisher: Vedams Books International, New Delhi.
11. Panda, H. (2011). *The Complete Technology Book on Biofertilizer and Organic Farming* (2nd ed.). Asia Pacific Business Press Inc. ISBN: 978-9380772880. Publisher: National Institute of Industrial Re-search, New Delhi.

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Four Year Undergraduate Programme (Botany) Syllabus, Semester-VIII	
Session 2029-2030	
Part-A Introduction	
Subject	**Botany**
Semester	**VIII**
Name of the Course	Advanced Tools & Analytical Techniques in Plant Biology
Course Code	**08/BOT/DSE/475T**
Course Type:	DSE
Level of the course (As per Annexure-I)	400-499
Advance Courses	
Course Learning Outcomes (CLO)	After completing the course: CLO1: Understand electron microscopy, chromosome imaging, and centrifugation techniques. CLO2: Learn use of radioisotopes and autoradiography with biosafety measures. CLO3: Understand spectrophotometry, mass spectrometry, X-ray methods, and electrophoresis. CLO4: Learn principles of chromatographic techniques for biomolecule separation. CLO5: Develop skills in PCR, DNA/protein analysis, blotting, sequencing, and ELISA.
Credits	3+1=4
Total Marks	15+60=75 Theory and 5+20=25 Practical; Total Marks=100
Part-B Contents of the Course	
Total lecture per week	3Theory+2Practical=5hr

Units	**Topics**	**No. of Lecture/Contact Hours**
I	Imaging and related techniques: Electron microscopy: Transmission and Scanning electron microscopy, cryofixation, negative staining, shadow casting, freeze-fracture, freeze-etching; Chromosome banding, FISH, GISH, chromosome painting. Centrifugation: types of rotors, differential and density gradient centrifugation, sucrose density gradient, ultracentrifugation, caesium chloride gradient; marker enzymes for analysis of cellular fractions.	9
II	Radioisotopes: Types of radioisotopes; types of emissions (alpha, beta, gamma radiations); half-life; use of radioisotopes in biological research; auto-radiography; pulse-chase experiment; Biosafety measures and disposal of radioactive material	9
III	Spectrophotometry: Principles and applications of UV, Visible and IR spectrophotometry, Mass spectrometry; X-ray diffraction; X-ray crystallography; Electrophoresis: AGE, PAGE, SDS-PAGE	9
IV	Chromatography: Principles and applications of Paper chromatography, Column chromatography, TLC, GLC, HPLC, Ion-exchange chromatography, Molecular sieve chromatography, Affinity chromatography.	9

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V	Techniques for detection and analysis of nucleic acids and proteins: PCR – design of PCR primers, enzymes used for PCR, cloning of PCR products; DNA polymorphism and its applications (RFLP, AFLP, SSR, SNPs); RNA isolation and analysis, cDNA synthesis and qRT-PCR; Extraction of proteins, PAGE (Native and denaturing); Blotting and hybridization techniques: Southern (Radioactive and Non-radioactive), Northern and Western; DNA sequencing – Sanger's dideoxy sequencing; ELISA.	9

Laboratory exercise

Credits	Hours	Marks	Total Hr
1	**2**	**5+20=25**	**30**

1. Study of microscopic techniques using digital resources (freeze-fracture, freeze-etching, negative staining, FISH, chromosome banding).
2. Isolation of chloroplasts by differential centrifugation.
3. Separation of nitrogenous bases by paper chromatography.
4. Separation of sugars by thin layer chromatography
5. Separation of chloroplast pigments by column chromatography (demonstration)
6. Amplification of DNA by PCR and visualization of PCR products.
7. Detection of DNA polymorphism (SSR based DNA fingerprinting).
8. Gel based and capillary based DNA sequence data analysis.
9. Estimation of protein concentration by Bradford method.
10. PAGE to study overexpression of proteins/ Separation of proteins by PAGE.
11. Blotting techniques: Southern, Northern and Western using digital resources.

Suggested Reading

1. Hofmann, A., &Clokie, S. (2018) Wilson and Walker's Principles and Techniques of Biochemistry and Molecular Biology (8th ed.). Cambridge University Press.
2. Gerald Karp, Janet Iwasa, Wallace Marshall (2019). Karp's Cell and Molecular Biology, 9th Edition: Wiley
3. O' Brien, T.P. and Cully M.E (1981). The Study of Plant Structure. Principles and selected Methods, Termarcarphi Pty. Ltd., Melbourne.
4. Kalra, Y. P. (Ed.). (1998). *Handbook of reference methods for plant analysis*. CRC Press.
5. Stewart, C. N., Jr. (2016). *Plant biotechnology and genetics: Principles, techniques, and applications* (2nd ed.). Wiley.
6. *Modern methods of plant analysis* (Vols. 1–6). (1984–1996). Springer.
7. Pandey, B. P. (2014). *Analytical techniques in plant sciences: Botany for B.Sc. semester text*. Schand Publishing.
8. *Plant cell biology from laboratory techniques to leading-edge methods*. (2024). Oxford University Press.
9. Taiz, L., Zeiger, E., Møller, I. M., & Murphy, A. (2015). *Plant physiology and development* (6th ed.). Sinauer Associates.
10. Davies, P. J. (Ed.). (2010). *Plant hormones: Biosynthesis, signal transduction, action!* (3rd ed.). Springer.
11. Fosket, D. E. (1994). *Plant growth and development: A molecular approach*. Academic Press.
12. Cooper, G.M., Hausman, R .E. (2009). The Cell: A Molecular Approach, 5th edition. Washington, D.C.: ASM Press & Sunderland, Sinauer Associates, MA.

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Four Year Undergraduate Programme (Botany) Syllabus, Semester-VIII	
Session 2029-2030	
Part-A Introduction	
Subject	**Botany**
Semester	**VIII**
Name of the Course	Molecular Ecology
Course Code	**08/BOT/DSE/476T**
Course Type:	DSE
Level of the course (As per Annexure-I)	400-499
Advance Courses	
Course Learning Outcomes (CLO)	After completing the course: CLO1: Understand basic concepts of molecular ecology and ecological interactions CLO2: Explain genetic variation and population structure in natural populations CLO3: Apply molecular tools for biodiversity assessment and ecological studies CLO4: Analyze ecological patterns using simple genetic and spatial concepts CLO5: Understand applications of molecular ecology in conservation and the environment
Credits	3+1=4
Total Marks	15+60=75 Theory and 5+20=25 Practical; Total Marks=100
Part-B Contents of the Course	
Total lecture per week	3Theory+2Practical=5hr

Units	**Topics**	**No. of Lecture/Contact Hours**
I	Molecular Ecology: definition, history, scope and significance in modern ecology. Molecular tools in ecological studies. Ecological interactions: mutualism, competition and adaptation. Basic idea of evolution and Neutral Theory.	9
II	Concept of genetic diversity and variation in populations. Forces affecting genetic variation: natural selection, genetic drift and gene flow. Basic population structure and gene pool. Sources of variation: mutation and transposons (introductory). Concept of Evolutionary Significant Units (ESUs).	9
III	Biogeographic patterns and species distribution. Habitat fragmentation and ecological connectivity. Introduction to environmental DNA (eDNA) and its applications in biodiversity monitoring. Basic concept of landscape genetics and spatial analysis.	9
IV	Introduction to molecular markers: dominant and co-dominant markers (basic concept). DNA barcoding and its role in species identification. Applications in biodiversity assessment and conservation. Simple genotyping approaches.	9
V	Hardy–Weinberg equilibrium (basic concept and simple calculations). Introduction to genetic parameters: gene frequency, gene flow and population differentiation. Basic idea of ecological genomics, metabolomics and gene	9

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	expression in ecological studies. Applications in conservation biology and environmental monitoring.	

Laboratory exercise

Credits	Hours	Marks	Total Hr
1	2	5+20=25	30

1. DNA extraction from plant material from any standard method
2. Observation and interpretation of DNA quality using gel image/data.
3. Basic primer design concept using given DNA sequence (theoretical exercise).
4. Separation of plant metabolites using TLC (demonstration/analysis).
5. Simple Hardy–Weinberg calculation using given data set.
6. Measurement of enzyme activity in diverse habitat plants and its ecological significance.
7. Field sampling and biodiversity survey of local area (record species diversity).
8. Preparation of biodiversity data table and simple analysis.
9. Interpretation of genetic variation using given sample data (F-statistics concept).
10. Preparation of short project/report on molecular ecology application in conservation.

Suggested Reading

1. Freeland, J. R., Petersen, S. D., & Butlin, R. K. (2006). *Molecular ecology*. Wiley.
2. Rowe, G., Sweet, M., & Beebee, T. J. C. (2017). *An introduction to molecular ecology*. Oxford University Press.
3. Schierwater, B., & DeSalle, R. (2012). *Molecular approaches to ecology and evolution*. Springer.
4. Nei, M., & Kumar, S. (2000). *Molecular evolution and phylogenetics*. Oxford University Press.
5. Taberlet, P., Bonin, A., Zinger, L., & Coissac, E. (2018). *Environmental DNA: For biodiversity research and monitoring*. Oxford University Press.

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Four Year Undergraduate Programme (Botany) Syllabus, Semester-VIII	
Session 2029-2030	
Part-A Introduction	
Subject	**Botany**
Semester	**VIII**
Name of the Course	**RESEARCH PROJECT/DISSERTATION**
Course Code	**08/BOT/RP&D/452**
Course Type:	**RP&D**
Level of the course (As per Annexure-I)	400-499
Advance Courses	
Course Learning Outcomes (CLO)	After completing the course: CLO1: Formulate a clear, feasible research problem and define specific objectives and hypotheses. CLO2: Plan and conduct an independent research project using appropriate experimental or field methods and statistical analysis. CLO3: Collect, organize, and interpret data systematically, and present results in tables, figures, and clear scientific language. CLO4: Synthesize findings with existing literature and write a well-structured dissertation (introduction, methods, results, discussion, conclusion). CLO5: Present and defend the research work orally and apply research-communication skills for scientific reporting and possible publication.
Credits	12
Total Marks	300 MARKS

RESEARCH PROJECT/DISSERTATION IN HONOURS WITH RESEARCH PROGRAMME

- Students who secure 75% marks and above (equivalently, CGPA 7.5 and above) cumulatively in the first six semesters are eligible to get selected to Honours with Research stream in the fourth year.
- A relaxation of as per the admission rule of JNVU
- In Honours with Research programme, the student has to do a mandatory Research Project of 12-credits instead of three Core Courses in Major in semester 8.
- The approved research centres of JAI NARAIN VYAS UNIVERSITY (JNVU) or any other university/ HEI can offer the Honours with Research programme. The departments in the affiliated colleges under JNVU, which are not the approved research centres of the University, should get prior approval from the University to offer the Honours with Research programme. Such departments should have minimum two faculty members with Ph.D., and they should also have the necessary infrastructure to offer Honours with Research programme.
- A faculty member of the University/ College with a Ph.D. degree can supervise the **research project/dissertation** of the students who have enrolled for Honours with Research. One such faculty member can supervise maximum five students in Honours with the Research stream.

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- The maximum intake of the department for Honours with Research programme is fixed by the department based on the number of faculty members eligible for project supervision, and other academic, research, and infrastructural facilities available.
- If a greater number of eligible students are opting for the Honours with Research programme than the number of available seats, then the allotment shall be based on the existing rules of reservations and merits.

GUIDELINES FOR THE RESEARCH PROJECT/DISSERTATION HONOURS WITH RESEARCH PROGRAMME

- Project can be in Botany or allied disciplines.
- Project should be done individually.
- Project work can be of experimental/ theoretical/ exploration in nature.
- There should be minimum 360 hrs. of engagement from the student in the Project work in Honours programme as well as in Honours with Research programme.
- There should be minimum 13 hrs./week of engagement (the hours corresponding to the three core courses in Major in semester 8) from the teacher in the guidance of the Project(s) in Honours programme and Honours with Research programme.
- The various steps in project works are the following:
  1. Wide review of a topic.
  2. Investigation on a problem in systematic way using appropriate techniques.
  3. Systematic recording of the work.
  4. Reporting the results with interpretation/statistical analysis in a standard documented form.
  5. Presenting the results before the examiners.
- During the **research project/dissertation**, the students should make regular and detailed entries into a personal log book throughout the period of investigation. The log book will be a record of the progress of the **research project/dissertation** and the time spent on the work, and it will be useful in writing the final report. It may contain experimental conditions and results, ideas, methodologies, rough work and calculation, etc. All entries should be dated. The Project supervisor should periodically examine and countersign the logbook.
- The logbook and the typed report must be submitted at the end of the **research project/dissertation**. A copy of the report should be kept for reference in the department. A soft copy of the report, too, should be submitted to be sent to the external examiner in advance.
- It is desirable, but not mandatory, to publish the results of the Project in a peer-reviewed journal.
- The **research project/dissertation** shall have an undertaking from the student and a certificate from the research supervisor for originality of the work, stating that there is no plagiarism, and that the work has not been submitted for the award of any other degree/ diploma in the same institution or any other institution.
- The project proposal, institution at which the **research project/dissertation** is being carried out, and the project supervisor should be prior-approved by the Department Council of the college where the student has enrolled for the UG Honours Programme.

PROFESSOR & HEAD
DEPARTMENT OF BOTANY
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