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**	**MJR**	**08/BOT/MJR/101T**	Microbiology, Mycology and Plant Pathology	**L**	**-**	4	60	**4**	**4**	**20**	**80**	**100**
4.5		**MJR-P**	**08/BOT/MJR/101P**	Practical for Microbiology, Mycology and Plant Pathology		P	4	60	**2**	**2**	**10**	**40**	**50**
4.5	**I**	**MJR**	**08/BOT/MJR/102T**	Phycology, Lichenology and Bryology	**L**		4	60	**4**	**4**	**20**	**80**	**100**
4.5		**MJR-P**	**08/BOT/MJR/102P**	Practical for Phycology, Lichenology and Bryology		P	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**	**MJR**	**08/BOT/MJR/151T**	Pteridology, Gymnosperms and Paleobotany	**L**	**-**	4	60	**4**	**4**	**20**	**80**	**100**
4.5		**MJR-P**	**08/BOT/MJR/151P**	Practical for Pteridology, Gymnosperms and Paleobotany		P	4	60	**2**	**2**	**10**	**40**	**50**
4.5	**II**	**MJR**	**08/BOT/MJR/152T**	Morphology and Anatomy of Angiosperms	**L**		4	60	**4**	**4**	**20**	**80**	**100**
4.5		**MJR-P**	**08/BOT/MJR/152P**	Practical for Morphology and Anatomy of Angiosperms		P	4	60	**2**	**2**	**10**	**40**	**50**

SEMESTER III														
NHEQF Level	**Semester***	**Course Type**	**Course Code**	**Course Title**	**L**	**P**	**H/W**	**Total Hour s**	**Credits**	**Total Credits**	**CA Marks**	**EoSE Marks**	**M.M.**
5	**III**	**MJR**	**08/BOT/MJR/201T**	Taxonomy and Embryology of Angiosperms	**L**	**-**	4	60	**4**	**4**	**20**	**80**	**100**
5		**MJR-P**	**08/BOT/MJR/201P**	Practical for Taxonomy and Embryology of Angiosperms		P	4	60	**2**	**2**	**10**	**40**	**50**
5	**III**	**MJR**	**08/BOT/MJR/202T**	Economic Botany and Ethnobotany	**L**	**-**	4	60	**4**	**4**	**20**	**80**	**100**
5		**MJR-P**	**08/BOT/MJR/202P**	Practical for Economic Botany and Ethnobotany		P	4	60	**2**	**2**	**10**	**40**	**50**

SEMESTER IV													
NHEQF Level	**Semester***	**Course Type**	**Course Code**	**Course Title**	**L**	**P**	**H/W**	**Total Hour s**	**Credits**	**Total Credits**	**CA Marks**	**EoSE Marks**	**M.M.**
5	**IV**	**MJR**	**08/BOT/MJR/251T**	Cell Biology and Cytology	**L**	**-**	4	60	**4**	**4**	**20**	**80**	**100**
5		**MJR-P**	**08/BOT/MJR/251P**	Practical for Cell Biology and Cytology		P	4	60	**2**	**2**	**10**	**40**	**50**
5	**IV**	**MJR**	**08/BOT/MJR/252T**	Genetics, Cytogenetics and Plant Breeding	**L**	**-**	4	60	**4**	**4**	**20**	**80**	**100**
5		**MJR-P**	**08/BOT/MJR/252P**	Practical for Genetics, Cytogenetics and Plant Breeding		P	4	60	**2**	**2**	**10**	**40**	**50**

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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**	**MJR**	**08/BOT/MJR/301T**	Plant Ecology and Environmental Science	**L**	**-**	4	60	**4**	**4**	**20**	**80**	**100**
5.5	**V**	**MJR-P**	**08/BOT/MJR/301P**	Practical for Plant Ecology and Environmental Science		P	4	60	**2**	**2**	**10**	**40**	**50**
5.5	**V**	**MJR**	**08/BOT/MJR/302T**	Plant Physiology and Metabolism	**L**	**-**	4	60	**4**	**4**	**20**	**80**	**100**
5.5	**V**	**MJR-P**	**08/BOT/MJR/302P**	Practical for Plant Physiology and Metabolism		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**	**MJR**	**08/BOT/MJR/351T**	Molecular Biology	**L**	**-**	4	60	**4**	**4**	**20**	**80**	**100**
5.5		**MJR-P**	**08/BOT/MJR/353P**	Practical for Molecular Biology		P	4	60	**2**	**2**	**10**	**40**	**50**
5.5	**VI**	**MJR**	**08/BOT/MJR/352T**	Plant Biotechnology	**L**	**-**	4	60	**4**	**4**	**20**	**80**	**100**
5.5		**MJR-P**	**08/BOT/MJR/352P**	Practical for Plant 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**	**MJR**	**08/BOT/MJR/401T**	Cell and Molecular Biology	**L**	**-**	4	60	**4**	**4**	**20**	**80**	**100**
6		**MJR-P**	**08/BOT/MJR/401P**	Practical for Cell and Molecular Biology		P	4	60	**2**	**2**	**10**	**40**	**50**
6	**VII**	**MJR**	**08/BOT/MJR/402T**	Theoretical and applied Ecology	**L**	**-**	4	60	**4**	**4**	**20**	**80**	**100**
6			**08/BOT/MJR/402P**	Practical for Theoretical and applied Ecology		P	4	60	**2**	**2**	**10**	**40**	**50**
6	**VII**	**MJR**	**08/BOT/MJR/403T**	Advances in the Diversity of Seed Plants	**L**	**-**	4	60	**4**	**4**	**20**	**80**	**100**
6		**MJR-P**	**08/BOT/MJR/403P**	Practical for Advances in the Diversity of Seed Plants		P	4	60	**2**	**2**	**10**	**40**	**50**

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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**	**MJR**	**08/BOT/MJR/451T**	Advances in Plant Development and Reproductive Biology	**L-**		4	60	**4**	**4**	**20**	**80**	**100**
6		**MJR-P**	**08/BOT/MJR/451P**	Practical for Advances in Plant Development and Reproductive Biology		P	4	60	**2**	**2**	**10**	**40**	**50**
6	**VIII**	**MJR**	**08/BOT/MJR/452T**	Advances in Plant Physiology and Metabolism	**L-**		4	60	**4**	**4**	**20**	**80**	**100**
6		**MJR-P**	**08/BOT/MJR/452P**	Practical for Advances in Plant Physiology and Metabolism		P	4	60	**2**	**2**	**10**	**40**	**50**

SEMESTER VIII Honours with Research Programme													
6	**VIII**	**MJR**	**08/BOT/MJR/451T**	Advances in Plant Development and Reproductive Biology	**L-**		4	60	**4**	**4**	**20**	**80**	**100**
			08/BOT/MJR/451P	Practical for Advances in Plant Development and Reproductive Biology		P	4	60	**2**	**2**	**10**	**40**	**50**
6	**VIII**	**MJR**	**08/BOT/MJR/452T**	Advances in Plant Physiology and Metabolism	**L-**		4	60	**4**	**4**	**20**	**80**	**100**
			08/BOT/MJR/452P	Practical for Advances in Plant Development and Reproductive Biology		P	4	60	**2**	**2**	**10**	**40**	**50**
		RP/D	**08/BOT/RP&D/452**	Research Project/Dissertation		P			12	12			300
									24	**24**	**10**	**480**	**600**

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

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CORE COURSES IN MAJOR

SEMESTER	COURSE TYPE	COURSE CODE
I	Microbiology, Mycology and Plant Pathology	**08/BOT/MJR/101T**
	Phycology, Lichenology and Bryology	**08/BOT/MJR/102T**
II	Pteridology, Gymnosperms and Paleobotany	**08/BOT/MJR/151T**
	Morphology and Anatomy of Angiosperms	**08/BOT/MJR/152T**
III	Taxonomy and Embryology of Angiosperms	**08/BOT/MJR/201T**
	Economic Botany and Ethnobotany	**08/BOT/MJR/202T**
IV	Cell biology and Cytology	**08/BOT/MJR/251T**
	Genetics, Cytogenetics and Plant Breeding	**08/BOT/MJR/252T**
V	Plant Ecology and Environmental Science	**08/BOT/MJR/301T**
	Plant Physiology and Biochemistry	**08/BOT/MJR/302T**
VI	Molecular Biology	**08/BOT/MJR/351T**
	Plant Biotechnology	**08/BOT/MJR/352T**
VII	Cell and Molecular Biology	**08/BOT/MJR/401T**
	Theoretical and applied Ecology	**08/BOT/MJR/402T**
	Advances in Diversity of Seed Plants	**08/BOT/MJR/403T**
VIII	Advances in Plant Development and Reproductive Biology	**08/BOT/MJR/451T**
	Advances in Plant Physiology and Metabolism	**08/BOT/MJR/452T**

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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	Microbiology, Mycology and Plant Pathology
Course Code	**08/BOT/MJR/101T**
Course Type:	MJR (Major)
Level of the course (As per Annexure-I)	100-199
Foundation or Introductory Courses	
Course Learning Outcomes (CLO)	After completing the course: 1CLO 1: Understand of the diversity of Microbes and Fungi with their significances. CLO 2: Understand of identify the microbes and fungi on the basis of their morphological characteristics. CLO 3: Understand the principles and methods of plant pathology CLO 4: Understand the plant disease management. CLO 5: Understand the side effect of synthesis fungicides.
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	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 with life cycle of *Albugo*. Characteristics features of Zygomycotina with life cycle of *Rhizopus*. Characteristics features of Ascomycotina with life cycle of Penicillium.	12
IV	Characteristics features of Basidiomycotina with life cycle of Puccinia. Characteristics features of Deuteromycotina with life cycle of *Alternaria*. Economic importance of Fungi. Edible Fungi: Mushroom (*Agaricus*) and Morel (Morchella). Mycorrhizae: General account and ecological significance.	12
V	General account and life cycle of White rust of crucifer, Rust of wheat, Citrus canker, Little leaf of brinjal and Root knot disease of vegetable. General account of Plant Disease management with special reference to physical, chemical and biological measures.	12

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08/BOT/MJR/101P: Practical for Microbiology, Mycology and Plant Pathology

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

Laboratory Exercises:

1. Virus: Morphotype of TMV and Bacteriophage (Specimen/Photographs)
2. Phytoplasma and Mycoplasma (Slide/Photographs)
3. Eubacteria: Microscopic preparation and study of Gram staining and Acid-fast staining. Root nodules –Rhizobia bacteria (specimen),
4. Cyanobacteria: Microscopic preparation and study of Nostoc.
5. Fungi: Microscopic preparation and study of following materials: *Albugo*, *Rhizopus*, *Penicillium*, *Puccinia*, *Agaricus* and *Alternaria*.
6. Plant Pathology: Disease symptoms, causal organism, disease cycle and disease management of White rust of crucifers, Rust of wheat, Citrus canker, Little leaf of brinjal and Root knot disease of vegetables.

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., Alexopoulous,C.J. and Delevoryas, T. Morphology of Plant and Fungi (4th Ed.) Harper & 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 2000 Volume I, Vikas Pub. House Pvt. Ltd., New Delhi.
8. Sharma, P.D. Microbiology and Plant Pathology, Rastogi Publ. Meerut, 2003.
9. Singh, V., Pande, P.C. and Jain, D.K. A Text Book of Botany, Rastogi & Co., Meerut, 2001.
10. 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-I	
Session 2026-2027	
Part-A Introduction	
Subject	**Botany**
Semester	**I**
Name of the Course	Phycology, Lichenology and Bryology
Course Code	**08/BOT/MJR/102T**
Course Type:	MJR (Major)
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 of algae and their and life cycles CLO: 2 Understand the economic importance of algae. CLO: 3 Identify various type of Lichens and their significances. CLO: 4 Understand the Diversity and structure of Bryophyta with their life cycles. CLO: 5 Understand the ecological and economic importance of Bryophyta.
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	General Character and Classification of Algae. Characteristics features of Chlorophyceae with life cycle of *Volvox* and Charophyceae with life cycle of *Chara*.	12
II	Characteristics features of Xanthophyceae and Phaeophyceae with life cycle of *Ectocarpus*. Characteristics features of Rhodophyceae with life cycle of *Polysiphonia*. Economic importance of Algae.	12
III	General character and classification of Lichen. External morphology of *Rhizocarpon, Parmelia and Usnea*. Ecological significances and economic importance of Lichens.	12
IV	General Characters, classification and alternation of generation of Bryophyta. Characteristics features of Hepaticopsida. Structure and life form of *Riccia* and *Marchantia*	12
V	Characteristics features of Anthocerotopsida and life form of *Anthoceros.* Characteristics features of Bryopsida. Structure and life form of *Sphagnum*. Economic importance of Bryophyta.	12

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08/BOT/MJR/102P: Practical for Phycology, Lichenology and Bryology

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

Laboratory Exercises:

1. Algae: Microscopic preparation and study of following alga: *Volvox, Chara, Ectocarpus, and Polysiphonia*.
2. Lichen: Study of *Rhizocarpon, Parmelia* and *Usnea.*
3. Bryophyta: Study of external morphology and microscopic preparation of following Bryophytes genera:
   i. *Riccia* (External morphology, VTS of thallus, male and female sex organ, sporophyte).
   ii. *Marchantia* (External morphology, VTS of thallus through gemma cup, male and female sex organs and sporophyte).
   iii. *Anthoceros* (External morphology, VTS of thallus and sporophyte).
   iv. *Sphagnum* (External morphology and mounting of single leaf).

Recommended Books:

1. Lee, R. E. (2008). Phycology (4th ed.). Cambridge University Press.
2. Wehr, J. D., Sheath, R. G., & Ford, L. A. (2015). Freshwater algae of North America: Ecology and classification (2nd ed.). Academic Press / Sinauer Associates.
3. Graham, L. E., Graham, J. M., Wilcox, L. W., & Cook, M. E. (2009). Algae (2nd ed.). Benjamin Cummings.
4. South, G., & Whittick, A. (2009). An introduction to phycology (2nd ed.). Wiley-Blackwell.
5. Brodo, I. M., Sharnoff, S. D., & Sharnoff, S. (2001). Lichens of North America. Yale University Press.
6. Nash, T. H., III. (2008). Lichen biology (2nd ed.). Cambridge University Press.
7. Honegger, R., & Hawksworth, D. L. (2018). Lichens: Biology and ecology (2nd ed.). Cambridge University Press.
8. Shaw, A. J., & Goffinet, B. (Eds.). (2006). Bryophyte biology (2nd ed.). Cambridge University Press.
9. Glime, J. M. (Ed.). (2013–2017). Bryophyte ecology (Vols. 1–3). Michigan Technological University (electronic monograph).
10. Sivakumar, K. (2024). Textbook of phycology and bryology (latest edition). Daya Publishing House. (ISBN: 978-93-5461-728-7)
11. Siddiqui, K. A. (2013). A text book of botany: Diversity of algae, lichens and bryophytes (as per UGC-based undergrad syllabus; later reprints, e.g., 2019 public domain SLM). Uttarakhand Open University. (ISBN: 978-93-857-40-58-9; edition year: 2019)
12. Sreekumar, S., Remya, R., & Vijayakumaran Nair, K. (2019). Microbiology, phycology, mycology, lichenology and plant pathology (1st ed.). NEHU / Indian publisher. (Indian university-syllabus-oriented text)
13. Arumugam, N., Ragland, A., & Kumaresan, V. (2021). Mycology, plant pathology and lichenology (1st ed.). Saras Publications. (ISBN: 978-93-8245-935-4)
14. 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	Pteridophyte, Gymnosperms and Paleobotany
Course Code	**08/BOT/MJR/151T**
Course Type:	MJR (Major)
Level of the course (As per Annexure-I)	100-199
Foundation or Introductory Courses	
Course Learning Outcomes (CLO)	After completing the course: CLO1: Understand classification and general characters of pteridophytes, gymnosperms, and fossil plants. CLO2: Describe morphology, anatomy, and reproduction of important genera. CLO3: Explain key concepts such as stelar system, heterospory, and seed habit. CLO4: Interpret geological time scale and fossil studies. CLO5: Evaluate economic importance
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	**Pteridophyta:** General characters and classification. Stelar system. Salient features of Psilophyta; Morphology, anatomy and reproduction of *Psilotum*. Salient features of Lycophyta; Morphology, anatomy and reproduction of *Lycopodium* and *Sellaginella*.	12
II	**Pteridophyta:** Salient features of Sphenophyta; Morphology, anatomy and reproduction of *Equisetum*. Salient features of Pteropsida; Morphology, anatomy and reproduction of *Adiantum* and *Marsilea*. Heterospory and seed habit, Apospory and apogamy, Economic importance of Pteridophytes.	12
III	**Gymnosperms:** General characters and classification. Diversity and distribution of Gymnosperms in India. Salient features of Cycadophyta; Morphology, anatomy and reproduction of *Cycas.*	12
IV	**Gymnosperms:** Salient features of Coniferophyta; Morphology, anatomy and reproduction of *Pinus*. Salient features of Gnetophyta; Morphology, anatomy and reproduction of *Ephedra*. Economic importance of Gymnosperms.	12
V	**Palaeobotany:** Geological Time Scale. Fossilization and types of fossils. Nomenclature of fossils. Morphology, anatomy and reproduction of *Rhynia*. Morphology, anatomy and reproduction of *Williamsonia*. Contribution of Prof. Birbal Sahni to Palaeobotany.	12

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08/BOT/MJR/151P: Practical for Pteridology, Gymnosperms and Paleobotany

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

Laboratory Exercises

1. Pteridophyta: Study of morphology and microscopic preparation of followings:
   - i. *Lycopodium*: External morphology, T.S. of stem and L.S. of cone (slide)
   - ii. *Sellaginella*: External morphology, T.S. of stem and L.S. of cone
   - iii. *Equisetum*: External Morphology, T.S. of stem (Internode), and L.S. of cone (slide)
   - iv. *Marsilea*: External Morphology, T.S. of rhizome and H.L.S of sporocarp
   - v. *Adiantum*: External Morphology and L.S of sporophyll
2. Gymnosperm: Study of morphology and microscopic preparation of followings:
   - i. *Cycas*: External morphology, T.S. leaflet, Male cone, Female megasporophyll
   - ii. *Pinus*: External morphology, T.S. needle, Male cone, Pollen grains (mounting), Female cone
   - iii. *Ephedra*: External morphology, T.S. stem, Male flower (whole mounting), L.S. of ovules
3. Paleobotany: Study of specimen/photograph of following:
   - i. Fossil Pteridophyte: *Rhynia*
   - ii. Fossil Gymnosperm: *Willimsonia*
   - iii. Prof. Birbal Sahni

Recommended Books: Suggested Readings

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. Sporne, K.R. The Morphology of Gymnosperms, B.I. Publ. Pvt., Bombay, Calcutta, Delhi, 1991.
9. Wilson, N.S. and Rothewall, G.W. Palaeobotany and evolution of Plants, (2nd ed.), Cambridge University Press, U.K., 1993.

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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	Morphology and Anatomy Angiosperms
Course Code	**08/BOT/MJR/152T**
Course Type:	MJR (Major)
Level of the course (As per Annexure-I)	100-199
Foundation or Introductory Courses	
Course Learning Outcomes (CLO)	After completing the course: CLO1: Identify and describe the morphological features of vegetative and reproductive organs of angiosperms. CLO2: Differentiate between Monocot and Dicot anatomy, types of tissues, their structure, and functions CLO3: Understand the composition, internal structure & architecture of plants CLO4: Analyze anatomical adaptations of angiosperms to different environmental conditions CLO5: Demonstrate expertise in micro-technique, including staining and mounting thin sections for microscopic observation.
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	Morphological diversity in plant forms in annual, biennial and perennials; Type, function and modification of roots. General characteristics and function of stem and its modifications; Leaves- Types, phyllotaxy, stipules; diversity in shape and size, function and modifications of leaves	12
II	Flower- structure, floral symmetry, aestivation; floral whorls (petal, sepal, stamen and carpel), placentation types, adhesion and cohesion of floral parts; Inflorescence type: racemose, cymose, special types; Fruits- morphology and types--dry fruits, fleshy fruits, false fruits	12
III	Meristematic tissue- Classification of meristems based on origin, position, plane of division and function; histological organization of shoot apical meristem and Root apical meristem; Concept of tissue system, Simple and complex tissue	12
IV	Primary anatomy of root, stem and leaf of monocot and dicot; Cambium and its function, Secondary growth in stelar system: Formation of secondary	12

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	xylem, Secondary Phloem -structure and function, Growth rings, Porus and Non porous wood, Sap wood and Heart wood	
V	Secondary growth in extrastelar region-periderm formation; Abnormal primary and secondary growth in stems -*Nyctanthes, Boerhaavia, Leptadenia, Salvadora, Bignonia, Achyranthes and Dracaena*	12

08/BOT/MJR/152P: Practical for Morphology and Anatomy of Angiosperms

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

Laboratory Exercises

1. Distribution and types of parenchyma, collenchyma and sclerenchyma (Photographs / permanent slides)
2. Xylem tracheary elements-tracheids, vessel elements; thickenings; perforation plates; xylem fibres (Photographs / permanent slides)
3. Prepare temporary whole mounts/ sections to study root anatomy: monocot root- Maize, dicot root- *Tinospora*
4. Prepare temporary whole mounts/ sections to study stem anatomy: monocot stem Maize, Triticum; dicot stem- Sunflower, *Cucurbita*
5. Prepare temporary whole mounts/ sections to study abnormal secondary growth in stems - *Nyctanthes, Boerhaavia, Leptadenia, Salvadora, Bignonia, Achyranthes and Dracaena*
6. Prepare temporary whole mounts/ sections to study leaf anatomy: Maize and Nerium

Recommended Books:

1. Plant Form. An Illustrated Guide to Flowering Plant Morphology, Adrian D.Bell, Oxford University Press, ISBN 0-19-854279-8.
2. Taylor A. Steeves & Vipen K. Sawhney 2017.Essentials of Developmental Plant Anatomy, Oxford University Press.
3. Plant Anatomy, Third Edition. A.Fahn, Pergamon Press. ISBN 0-08-028030-7.
4. Hirendra Chandra Gangulee, Asok Kumar Kar. 2011, College Botany, Volume II
5. Dickison, W.C. 2000. Integrative Plant Anatomy. Harcourt Academic Press, USA.
6. Evert, R.F. 2006. Esau's Plant Anatomy: Meristems, Cells, and Tissues of the
7. Plant Body: Their Structure, Function and Development. John Wiley and Sons, Inc Fahn
8. Mauseth, J.D. 1988. Plant Anatomy. The Benjammin/Cummings Publisher, USA.
9. Pandey, B.P. 2001. Plant Anatomy, S. Chand Publishing, New Delhi.
10. Vasistha, P.C. 2000. Plant Anatomy, Pradeep Publications, Jalandhar

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Four Year Undergraduate Programme (Botany) Syllabus, Semester-III	
Session 2026-2027	
Part-A Introduction	
Subject	**Botany**
Semester	**III**
Name of the Course	Taxonomy and Embryology of Angiosperms
Course Code	**08/BOT/MJR/201T**
Course Type:	MJR
Level of the course (As per Annexure-I)	200-299
Intermediate-level Courses	
Course Learning Outcomes (CLO)	After completing the course: CLO1: Understand the principles of angiosperm taxonomy and apply rules of botanical nomenclature. CLO2: Recognize and classify plants into families based on morphological and diagnostic features. CLO3: Use taxonomic tools effectively and apply identification keys, herbarium techniques, and field methods. CLO4: Describe reproductive structures and their development CLO5: Interpret slides, diagrams, and specimens related to angiosperm structure and development.
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	Objectives and principle of taxonomy; holotaxonomy and Numerical taxonomy, Herbarium: Collection, preparation and preservation of plant specimens, Botanical gardens; Taxonomic literature- Flora, Manuals, Monograph and Icones	12
II	Salient features of ICN, Typification, Principle of priority, effective and valid publication; Artificial, Natural and Phylogenetic classification, Systems of classification – Bentham and Hooker, Engler and Prantle, Angiosperm Phylogeny Group (APG).	12
III	Diversity of flowering plants as illustrated by members of the families Ranunculaceae, Caryophyllaceae, Cucurbitaceae, Apiaceae, Asteraceae, Apocynaceae, Asclepiadaceae, Acanthaceae, Lamiaceae, Euphorbiaceae, and Poaceae. Taxonomic evidence- Anatomy, embryology and Phytochemistry	12
IV	Structure of Microsporangium, Microsporogenesis, Development of male gametophyte; Megasporangium – Structure of ovule, types of ovules, Megasporogenesis, Development of female gametophyte	12
V	Structure of mature embryo sac and its types; Pollination and fertilization, double fertilization, Types of Endosperms, development Dicot and Monocot embryo	12

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08/BOT/MJR/201P: Practical for Taxonomy and Embryology of Angiosperms

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. (Literature, herbaria, e-resources, taxonomic keys) and classify up to family level
3. (according to Bentham and Hooker's classification).
4. Description of taxa using semi-technical terms and identification of following families
5. according to Bentham and Hooker's classification.
6. Ranunculaceae (Ranunculus, Delphinium), Caryophyllaceae (Dianthus, Saponaria),
7. Cucurbitaceae (any Cucurbits), Apiaceae (Coriandrum), Asteraceae (Helianthus, Sonchus), Acanthaceae (Adhatoda, Barleria), Apocynaceae (Catharanthus, Thevetia, Nerium) , Asclepiadaceae (Calotropis), Lamiaceae (Ocimum,Salvia), Euphorbiaceae (Euphorbia pulcherrima, Ricinus) and Poaceae (Triticum)
8. Anther: Temporary stained mounts of T.S. anther (Datura) to study the structure.
9. To study the anther development and various stages through Photographs/permanent slides
10. To study the development and various type of ovule through Photographs/permanent slides
11. To study the development of embryo in monocot and dicot through Photographs/permanent slides

Recommended Books:

1. Davis, P. H. and V. H. Heywood. 1963. Principles of Angiosperm Taxonomy. Oliver and Boyd,London.
2. Heywood, V. H. and D. M. Moore (Eds). 1984. Current Concepts in Plant Taxonomy. Academic Press, London.
3. Plant Systematics. Arun K. Pandey & Shruti Kansana. 2020. Jaya Publishing House.
4. Stace, C. A. 1989. Plant Taxonomy and Biostatistics (2nd Ed.). Edward Arnold, London.
5. Singh, G. 1999. Plant Systematics: Theory and Practice. Oxford and IBH, New Delhi.
6. 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.
7. 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.
8. P. Maheshwari, (2004). An introduction to the embryology of Angiosperms. Tata
9. 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. Plant Systematics. Arun K. Pandey & Shruti Kansana. 2020. Jaya Publishing House.

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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	**Economic Botany and Ethnobotany**	
Course Code	**08/BOT/MJR/202T**	
Course Type:	MJR (Major)	
Level of the course (As per Annexure-I)	200-299	
Intermediate-level Courses		
Course Learning Outcomes (CLO)	After completing the course: CLO1: Classify economically important plants and understand the contribution of plant resources to livelihoods and national economy. CLO2: Suggest methods for sustainable use and conservation of useful plants. CLO3: Perform fieldwork, surveys, and documentation of plant uses. CLO4: Connect plant science with healthcare, agriculture, and economic development. CLO5: Describe the scope, importance, methods of ethnobotany and recognize traditional knowledge systems	
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	Origin of cultivated plants, Cereal, Millets, Legumes: Origin of agriculture, Centres of diversity of crop plants, Domestication and introduction of crop plants. Concept of sustainable development Botanical name, family, botany, Cultivation and uses of Wheat and Maize, Pearl Millet and Sorghum; Chickpea, Green Gram, Moth Bean	12
II	Oil crops, Fibre, and Timber; Botany, extraction and use of oils-Mustard, Sesame (Til) and Soyabean; Essential oil- Botany, extraction or distillation process of essential oil, Chemical constituents and utilisation- Lemon grass, Mentha, Rose, Lavender; General account of Fibre yielding plants, Extraction, Processing and uses of Cotton, and Jute; timber processing with special reference to Seesam, and Rohida	12
III	Dyes, Sugar and Starch, Medicinal Plants and Spices: Dyes: Botany, Classification and extraction process, uses of dye with special reference to Henna, and Kattha; Sugar and Starch- Propagation, Extraction/Processing of Sugar cane for sugar, Potato for starch Medicinal Plants- Botany, Cultivation, processing and uses of Aloe, Ashwagandha, Ephedra; Spices- Botanical name, family, Part used and chemical constituent of, Black Pepper, Coriander, turmeric, Cardamom, Fennel, Cumin and Clove	12

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IV	Ethnobotany: Introduction, concept, scope and objectives; Traditional Ethnobotany knowledge systems and practices of Tribal communities of Rajasthan and India. Role of plants in livelihood, ecological balance and sustainable development. Study of common plants used by the tribals for miscellaneous uses	12
V	Methodology of Ethnobotanical studies and medical aspects: Field work, Herbarium, Ancient Literature, Archaeological findings, temples, sacred groves, Orans. Tribal knowledge about plants towards disease diagnosis, treatment, plant conservation and cultivation. Ethnobotanical aspect of conservation and management of plant resources.	12

08/BOT/MJR/202P: Practical for Economic Botany and Ethnobotany

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

Laboratory Exercises

1. Cereals: habit sketch, L.S./T.S. of grain, starch grains, micro-chemical tests
2. Legume: Pea or ground nut (habit, fruit, seed structure, micro-chemical tests)
3. Source of sugars and starches: Sugarcane (habit sketch; cane juice- micro-chemical tests);potato (habit sketch, tuber morphology, T.S. of tuber part to show localization of starch grains, W.M. of starch) grains, micro-chemical tests.
4. Mustard- plant specimen, seeds, tests for fat in crushed seeds
5. Timbers: Photographs / specimen of section of young stem.
6. Jute- specimen, transverse section of stem, tests for lignin on T.S. of stem and study of fiber following maceration technique.
7. Study of specimens of economic importance mentioned in syllabus
8. Study of common plants used by tribes. *Aegle marmelos, Ficus religiosa, Cynodon dactylon.*
9. Familiarize with at least 5 folk medicines and study the cultivation, extraction and its medicinal application.
10. Observe the plants of ethnobotanical importance in your area.

Recommended Books:

1. Kochhar, S.L. (2011). Economic Botany in the Tropics, MacMillan Publishers India Ltd., New Delhi. 4th edition.
2. Sambamurthy, AVSS & Subrahmanyam, NS (2000). Economic Botany of Crop Plants. Asiatech Publishers. New Delhi.
3. Sharma, OP. 1996. Hill's Economic Botany (Late Dr. AF Hill, adopted by OP Sharma). Tata McGraw Hill Co. Ltd., New Delhi.
4. Krishnamurthy, K.V. (2004). An Advanced Text book of Biodiversity - Principles and Practices. Oxford and IBH Publications Co. Pvt. Ltd. New Delhi
5. Kalsi, P. S. and Jagtap, S., 2012. Pharmaceutical medicinal and natural product chemistry. N.K. Mehra for Narosa Publishing House Pvt. Ltd. New Delhi.
6. Pullaiah, T., Krishnamurthy, K. V., & Bahadur, B. (Eds.). (2017). *Ethnobotany of India, Volume 5: The Indo-Gangetic Region and Central India*. CRC Press.
7. Cotton, Catherine M. *Ethnobotany: principles and applications*. 1996.
8. Website:https://ethnobotanyjournal.org/index.php/era

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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 Cytology
Course Code	**08/BOT/MJR/251T**
Course Type:	MJR (Major)
Level of the course (As per Annexure-I)	200-299
Intermediate-level Courses	
Course Learning Outcomes (CLO)	After completing the course: CLO1: understand origin of life. CLO2: understand structure and function of cells. CLO3: gain knowledge about prokaryotic and eukaryotic cell. CLO4: know about the cell organelles, membrane, and cytoskeleton. CLO5: gain knowledge of DNA structure, replication, translation and gene expression regulation.
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	Origin of life: Theories of spontaneous generation, abiogenesis and biogenesis. Biochemical origin of life: origin of earth, chemical origin of life. Biological evolution: primary organelles, evolution of oxygen. Experimental evidences of formation of organic compounds. The cell unit of life: discovery, concept and cell theory.	12
II	Prokaryotic and eukaryotic cells. Microscopy; Chemistry, structure and function: Plant cell wall, plasma membrane. Nucleus: nucleolus, nuclear envelope, nuclear pore complex, nuclear lamina.	12
III	Cell organelles: mitochondria, plastids, vacuole and peroxisomes, endoplasmic reticulum, Golgi apparatus, microtubules, microfilaments. Cell division and regulation of cell cycle; mitosis and meiosis.	12
IV	Chromosome structure and packaging of DNA. Specialized and sex chromosomes. Variation in chromosome number and structure: deletion, duplication, inversion, translocation and position effect, euploidy and aneuploidy.	12
V	Chromosome and inheritance. Linkage. Cytological basis of crossing over. chromosome mapping; linkage group and recombination frequency, interference and coincidence. Somatic cell hybridization.	12

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08/BOT/MJR/251P: Practical for Cell biology and Cytology

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

Laboratory Exercises

1. Demonstrate Louis Pasteur's experiment to disapprove theory of spontaneous generation.
2. Demonstrate/perform Stanley Miller's experiment on *in vitro* synthesis of complex organic compound.
3. Demonstrate various components of Microscopes.
4. Prepare various stains.
5. Mount epidermal peel of onion and stain it dilute safranin to observe cell wall, nucleus and cytoplasm.
6. Localize cell wall components (cellulose, pectin and lignin) of stem cuttings of *Salvadora*/*Capparis*.
7. Prepare a smear of root tip and flower bud of onion for study of various stages of mitosis and meiosis respectively.
8. Prepare a Karyotype.
9. Map a chromosome on the basis of recombination frequency.

Recommended Books:

1. Rastogi Bala V Organic evolution Kedar Nath Ram Nath Meerut.
2. Alberts, B., Bray, D., Lewis, J., Raff, M., Roberts, K. and Watson, J. D. 1999. Molecular Biology of the Cell. Garland Publishing, Inc., New York.
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. Lodish, H., Berk, A., Zipursky, S. L., Malsudaira, P., Baltimore, D. and Darnell, J. 2000.
5. Molecular Cell Biology (V Edition). W.H. Freeman and Co., New York, USA.
6. De, D. N. 2000. Plant Cell Vacuoles: An Introduction. CSIRO Publication, Collingwood, Australia.
7. Glick, B. R. and Thompson, J. E. 1993. Methods in Plant Molecular Biology and Biotechnology. CRC Press, Boca Raton, Florida.
8. De Robertis-Cell Biology

Suggested Readings (Laboratory Exercises)

9. Sambrook, J. and Russell D.W. 2001. Molecular Cloning: A Laboratory Manual. Cold Spring Harbor LaboratoryPress, Cold Spring Harbor, New York.
10. Gunning, B. E. S. and Steer, M. W. 1996. Plant Cell Biology: Structure and Function. Jones and Bartlett Publishers,Boston, Massachusetts.
11. Hall, J. L. and Moore, A. L. 1983. Isolation of Membranes and Organelles from Plant Cells. Academic Press,London, UK.
12. Krishnamurthy, K. V. 2000. Methods in Cell Wall Cytochemistry. CRC Press, Boca Raton, Florida.

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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	**Genetics, Cytogenetics and Plant Breeding**	
Course Code	**08/BOT/MJR/252T**	
Course Type:	MJR (Major)	
Level of the course (As per Annexure-I)	200-299	
Intermediate-level Courses		
Course Learning Outcomes (CLO)	After completing the course: CLO1: understand basics of genetics. CLO2: gain knowledge of DNA structure, replication, transcription, and translation. CLO3: understand gene expression regulation in pro and eukaryotes. CLO4: gain knowledge of physical and chemical basis of mutation. CLO5: understand fundamental and applied aspects of plant breeding.	
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	Genetics: Phenotype and genotype; classical and modern definition. Mendelian genetics: experiments and principles; segregation and independent assortment, exceptions of Mendelian inheritance. Genetic linkage and crossing-over.	12
II	DNA the genetic material: experimental proof of DNA as genetic material, DNA structure, and replication (prokaryotes and eukaryotes). Genetics of viruses, prokaryotes and eukaryotes. Genetic recombination in bacteria.	12
III	Classical vs molecular concepts of gene. Gene expression regulation in prokaryotes: lac operon, cAMP dependent lac operon, trp operon; coarse and fine tune regulation. Fine structure of genes. Regulation of gene expression in eukaryotes; organization of gene and mechanism of transcription. Introns and their significance.	12
IV	Gene mutations: types, molecular basis of physical and chemical mutations, detection of mutations: ClB method.Transposable elements in prokaryotes and eukaryotes. Role of mutation in plant improvement.	12
V	Centers of origin and domestication of crop plants. Concept of primary and secondary centers of origin of crop plants. Origin of agriculture. Plant genetic resources; introduction, acclimatization, selection, hybridization: self- and cross-pollinated plants. Role of male sterility and heterosis in plant breeding. Green revolution in India: history and achievements.	12

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08/BOT/MJR/252P: Practical for Genetics, Cytogenetics and Plant Breeding

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

Laboratory exercises

1. Perform cross between true breeding pea plants.
2. Demonstrate mono and di-hybrid crosses using checkerboard.
3. Demonstrate incomplete dominance and gene interaction through seed ratios (9:7, 9:6:1, 13:3, 15:1, 12:3:1, 9:3:4).
4. Analyze genetic linkage and crossing-over using photopraphs/diagrams.
5. Extract DNA from onion/pea/cauliflower using salt, detergent and pineapple juice.
6. Demonstrate electrophoresis.
7. Localize centers of origin of crop plants in world map.
8. Emasculate flower, bag it and label for cross-pollination.
9. Demonstrate hybridization of cross and self-pollinated crop species.
10. Perform seed/pollen viability test
11. Prepare smear for ploidy analysis.

Suggested readings

1. Snustad, D. P. and Simmons, M. J. 2000. Principles of Genetics (2nd edition). John Wiley & Sons Inc., USA.
2. Gardner E J, Simmons M J, Snustad D P 2006, Principles of Genetics, John Willey and Sons.
3. Hartl D L and Jones E W, Genetics Principles and Analysis, Jones and Bartlett Publishers.
4. Lewin, B. 2000. Genes VII, Oxford University Press, New York.
5. Glover, D. M. and Hames, B. D. (eds) 1995. DNA Cloning 1: A Practical Approach-, Core Techniques, 2ndedition,PAS, IRL Press at Oxford University Press, Oxford.
6. Dagla H. R. and Shekhawat N. S. Origin of Agriculture: Science Reporter (NISCAIR-CSIR), January, 2006.
7. Singh B. D. and Shekhawat N. S. 2019.Plant Breeding in 21st Century. Scientific Publisher, Jodhpur, India.
8. Singh B. D. 2012. Plant Breeding Principles and Methods. Kalyani Publisher. India.

Suggested Readings (Laboratory Exercises)

1. Sambrook, J. and Russell D.W. 2001. Molecular Cloning: A Laboratory Manual. Cold Spring Harbor LaboratoryPress, Cold Spring Harbor, New York.
2. Hackett, P. B., Fuchs, J. A. and Messing, J. W. 1988. An Introduction to Recombinant DNA Techniques: BasicExperiments in Gene Manipulation. The Benjamin/Cummings Publishing Co., Inc Menlo Park, California.

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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 Environmental Science	
Course Code	**08/BOT/MJR/301T**	
Course Type:	MJR (Major)	
Level of the course (As per Annexure-I)	300-399	
High-Level Courses		
Course Learning Outcomes (CLO)	After completing the course: CLO1: learn about the relationships between plants and their environment, including interaction with other biotic and abiotic factors. CLO2: gain a knowledge about the factors that influence the ecosystem dynamics. CLO3: learn about the environmental hazards, their causes, classification and impacts. CLO4: It also focuses on the management strategies and governmental action plan to mitigate and prepare for such hazards.	
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	Climate and Vegetation: Introduction to concepts and developments in Ecology. Atmosphere, Hydrosphere and Biosphere. Major biomes of the world. Vegetation types of India and Rajasthan.	12
II	Ecosystem: Structure and Function. Energy dynamics- energy flow models and efficiencies. C, N, P and S mineral cycles, their pathways, processes and global budget in terrestrial and aquatic systems.	12
III	Productivity and Plant Succesion: 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
IV	Natural Resources and their conservation: Energy resources, Mineral resources, Forest resources, Water and Soil resources. Ecological, social and economic dimension of resource management and conservation.	12
V	Natural hazards: Hydrological (Glacial Lake Outburst Floods, tornadoes, Cyclone, tsunamis and hurricanes), and Geological hazards (Earthquake, volcanic eruptions, landslides and drought) and their impacts.	12

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	Anthropogenic hazards: Impacts of anthropogenic activities like ground water extraction, deforestation, mangroves destruction, construction of dams and nuclear reactors in hazard prone zone.	

08/BOT/MJR/301P: Practical for Plant Ecology and Environmental Science

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

Laboratory/Field Exercises

1. To determine minimum size and number of quadrates required for reliable estimate of biomass in a natural field.
2. To estimate IVI of the species in protected and gochar land vegetation.
3. To determine diversity indices (concentration of dominance, Shannon-Wiener and Species richness) for protected and gochar land vegetation.
4. To estimate the organic carbon content of soil using modified Walkley and Black's rapid titration.
5. To quantitatively assess available phosphorus in given soil samples.
6. To quantify carbonate and bicarbonate concentration in water samples.
7. To quantitatively assess Chloride concentration by argentometric method in water samples.
8. To estimate salinity of water sample using chlorosity.
9. To estimate Dissolved Oxygen (DO) in different depths (0 and 15cm) of two water bodies.
10. Case Study on any natural hazard and prepare a comprehensive report of it.

Suggested Readings:

1. Schneid, T.D. & Collins, L. 2001. Disaster Management and Preparedness. Lewis Publishers, New York, NY.
2. Coppola D. P. 2007. Introduction to International Disaster Management. Butterworth Heinemann.
3. Cutter, S.L. 2012. Hazards Vulnerability and Environmental Justice. EarthScan, Routledge Press.
4. Keller, E. A. 1996. Introduction to Environmental Geology. Prentice Hall, Upper Saddle River, New Jersey.
5. Pine, J.C. 2009. Natural Hazards Analysis: Reducing the Impact of Disasters. CRC Press, Taylor and Francis Group.
6. Smith, K. 2001. Environmental Hazards: Assessing Risk and Reducing Disaster. Routledge Press.
7. Wallace, J.M. & Hobbs, P.V. 1977. Atmospheric Science: An Introductory Survey. Academic Press, New York.
8. Wasson, R.J., Sundriyal, Y.P., Chaudhary, S., Jaiswal, M.K., Morthekai, P., Sati, S.P.&Juyal, N. 2013. A 1000-year history of large floods in the upper Ganga catchment, central Himalaya, India. Quaternary Science Reviews 77: 156–166.

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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 Physiology and Metabolism	
Course Code	**08/BOT/MJR/302T**	
Course Type:	MJR (Major)	
Level of the course (As per Annexure-I)	300-399	
High-Level Courses		
Course Learning Outcomes (CLO)	After completing the course: CLO1: Explain plant water relations, including water potential, transpiration, and water transport mechanisms. Describe mineral nutrition and mechanisms of nutrient uptake along with deficiency symptoms. CLO2: Understand photosynthesis, including light reactions, carbon fixation pathways (C_3, C_4, CAM), and photorespiration. CLO3: Explain translocation of photoassimilates and the mechanism of phloem transport. CLO4: Analyze plant growth and development, including plant growth regulators and environmental responses. CLO5: Describe major metabolic pathways (glycolysis, TCA cycle, lipid and amino acid metabolism) and energy production in plants.	
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	Water as a solvent; cohesion and adhesion; Plant cell as an osmotic system; entry of water into cells; Water potential and its components; Transpiration: types, process and significance; Mechanism of stomatal movement; role of ABA and K^+ ions; Antitranspirants; Absorption of water: transpiration pull, cohesion of water molecules; Radial movement of water in roots; Soil-Plant-Atmosphere Continuum (SPAC); Mineral nutrition: macro and micronutrients; uptake and significance in plants.	12
II	Photosynthetic apparatus and pigments; Electromagnetic radiation and light absorption; Fluorescence and phosphorescence; Light harvesting complexes; Photosystems I and II; Electron transport and photophosphorylation; ATP and NADPH (assimilatory power); Carbon fixation pathways: C_3 cycle (Calvin cycle) and C_4 and CAM pathways (brief overview); Photorespiration: process and significance; Translocation of photo-assimilates; Phloem transport: pressure flow hypothesis; Phloem loading and unloading	12
III	Glycolysis pathway, Aerobic and anaerobic respiration; TCA cycle: steps and significance; Oxidative phosphorylation; Electron transport chain in	12

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	mitochondria; Chemiosmotic hypothesis; Cyanide-resistant respiration; Lipid metabolism: lipid structure and function, β-oxidation of fatty acids;	
I	Biological nitrogen fixation; Symbiotic nitrogen fixation in legumes; Biochemistry of nitrogen fixation; Ammonia assimilation and nitrate assimilation; Biosynthesis of amino acids; Amino acid metabolism Enzyme: Nomenclature Classification, Kinetics and enzyme regulation	12
V	Plant growth regulators: Auxins, Gibberellins, Cytokinins, Abscisic acid (ABA), Ethylene; Brassinosteroids; Physiological roles and commercial applications; Plant movements: Tropic andNastic movements; Photoperiodism and vernalization; Phytochrome: chemistry and role in photoperiodism; Seed dormancy and germination	12

08/BOT/MJR/302P: Practical for Plant Physiology and Biochemistry

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

Laboratory Exercise

1. Determination of osmotic potential by plasmolysis
2. Measurement of transpiration using potometer
3. Study of stomatal movement (leaf peel method)
4. Determination of water potential in plant tissue
5. Identification of mineral deficiency symptoms
6. Separation of photosynthetic pigments (paper chromatography)
7. Estimation of chlorophyll content
8. Demonstration of photosynthetic oxygen evolution
9. Effect of light intensity on photosynthesis
10. Bioassay of auxin (coleoptile elongation)
11. Study of phototropism and geotropism
12. Seed germination experiment
13. Estimation of reducing sugars
14. Estimation of proteins
15. Study of respiration using respirometer
16. Enzyme activity assay (catalase/peroxidase)
17. Paper chromatography of amino acids
18. Effect of inhibitors on respiration
19. Nitrate reductase activity assay
20. Extraction and estimation of lipids

Suggesting Readings

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. Buchanan, B. B., Gruissem, W., & Jones, R. L. (2015). Biochemistry and Molecular Biology of Plants (2nd ed.). ISBN: 978-1119623875. Publisher: John Wiley & Sons / ASPB.
3. Heldt, H.-W., & Piechulla, B. (2021). Plant Biochemistry (5th ed.). ISBN: 978-0128211448. Publisher: Academic Press / Elsevier.
4. Hopkins, W. G., & Hüner, N. P. A. (2020). Introduction to Plant Physiology (5th ed.). ISBN: 978-1119603797. Publisher: John Wiley & Sons.
5. Salisbury, F. B., & Ross, C. W. (2021). Plant Physiology (6th ed.). ISBN: 978-1119806213. Publisher: Wiley.
6. Verma, S. K., & Verma, M. (2025). A Textbook of Plant Physiology, Biochemistry and Biotechnology. ISBN: 9789355018764. Publisher: S. Chand Publishing.

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7. Jadon, D. K., & Singh, M. P. (2023). Plant Physiology, Metabolism & Biochemistry (Bilingual ed.). ISBN: 9789357602127. Publisher: Thakur Publication Private Limited.
8. Dennis, D. T., Turpin, D. H., Lefebvre, D. D., & Layzell, D. B. (Eds.). (2020). Plant Metabolism (3rd ed.). ISBN: 978-3030614143. Publisher: Springer.
9. Moorby, J., & Thornley, J. H. M. (2022). Plant Physiology for Sustainable Agriculture. ISBN: 9780128245034. Publisher: Academic Press.
10. Marschner, H., & Marschner, P. (2023). Marschner's Mineral Nutrition of Higher Plants (4th ed.). ISBN: 9780323917625. Publisher: Academic Press / Elsevier.
11. Fitter, A. H., & Hay, R. K. M. (2021). Environmental Physiology of Plants (4th ed.). ISBN: 9780124020620. Publisher: Academic Press.
12. Larcher, W. (2021). Physiological Plant Ecology: Ecophysiology and Stress Physiology (5th ed.). ISBN: 978-3030408391. Publisher: Springer.
13. Pessarakli, M. (Ed.). (2024). Handbook of Plant and Crop Physiology (4th ed.). ISBN: 9781032319513. Publisher: CRC Press / Taylor & Francis.
14. Tripathi, B. N., & Müller, M. (Eds.). (2022). Stress Responses in Plants: Mechanisms of Toxicity and Tolerance (2nd ed.). ISBN: 978-3031008876. Publisher: Springer.
15. Lea, P. J., & Leegood, R. C. (Eds.). (2023). Plant Biochemistry: A Metabolic Approach (Updated ed.). ISBN: 9780198577789. Publisher: Oxford University Press.

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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	Molecular Biology
Course Code	**08/BOT/MJR/351T**
Course Type:	MJR (Major)
Level of the course (As per Annexure-I)	300-399
High-Level Courses	
Course Learning Outcomes (CLO)	After completing the course: CLO1: understand basic concept of molecular biology. CLO1: gain knowledge of basic tools and techniques of molecular biology. CLO1: understand gene expression regulation CLO1: understand various means of isolation and separation of DNA, protein and RNA CLO1: gain knowledge of applications of molecular biology.
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	Central dogma of molecular biology: transcription and translation. Organization of prokaryotic and eukaryotic gene. Gene expression regulation in prokaryote and eukaryote.	12
II	Tools and techniques in molecular biology: Centrifugation, spectrophotometer, PAGE and agarose electrophoresis, PCR, DNA sequencing and mass spectrometry. Chromatography: principles and types.	12
III	Isolation and purification of DNA, RNA and Protein. Recombinant DNA technology: types and molecular mechanisms of nucleases, and ligases for cutting and joining of DNA. Separation and identification DNA, RNA and proteins by electrophoresis and blotting.	12
IV	Amplification of DNA, RNA by cloning vectors (plasmids, viruses and yeast) and PCRs. Molecular biology and applications of Agrobacterium tumefaciens and nitrogen fixing bacteria.	12
V	Principles and applications of molecular biology: biotechnology, pharmacogenomics, diagnostic, forensic, genomics, gene therapy. Protein and metabolic engineering: basic principles and applications.	12

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

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08/BOT/MJR/351P: Practical for Molecular Biology

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Laboratory Exercises

1. Extract DNA from given plant sample (Cauliflower/Onion) by Rapid Method.
2. Confirmative test of DNA using diphenyl amine (DPA).
3. Prepare PAGE.
4. Prepare agarose gel.
5. Load genomic DNA, RNA and protein on ge.l
6. Demonstrate working of Chromatography, PCR, Electrophoreses and Mass spectrometry
7. Set up an experiment for restriction digestion and ligation.
8. Draw a well labeled diagrams of Cloning vectors: Ti plasmid, pUC8, ColE1, pSC10, p-BR322, PAC, YAC and BAC.
9. Draw a labeled diagram of molecular organization of Agrobacterium tumefaciens.
10. Draw a labeled diagram of genetic makeup of Golden rice, Bt cotton.

Recommended Books:

1. Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P. (2014). *Molecular Biology of the Cell* (6th ed.). Garland Science.
2. Watson, J. D., Baker, T. A., Bell, S. P., Gann, A., Levine, M., & Losick, R. (2013). *Molecular Biology of the Gene* (7th ed.). Cold Spring Harbor Laboratory Press.
3. Cooper, G. M., & Hausman, R. E. (2019). *The Cell: A Molecular Approach* (9th ed.). Sinauer Associates.
4. Krebs, J. E., Goldstein, E. S., & Kilpatrick, S. T. (2013). *Lewin's Essential Genes* (3rd ed.). Jones & Bartlett Learning.
5. Karp, G. (2010). *Cell and Molecular Biology: Concepts and Experiments* (7th ed.). John Wiley & Sons.
6. Lodish, H., Berk, A., Zipursky, S. L., Matsudaira, P., Baltimore, D., & Darnell, J. (2000). *Molecular Cell Biology* (4th ed.). W.H. Freeman.
7. De Robertis, E. D. P., & De Robertis, E. M. F. (2006). *Cell and Molecular Biology* (8th ed.). Lippincott Williams & Wilkins.
8. Twyman, R. M. (1998). *Advanced Molecular Biology: A Concise Reference*. Bios Scientific Publishers.
9. Ptashne, M. (2004). *A Genetic Switch: Phage Lambda Revisited* (3rd ed.). Cold Spring Harbor Laboratory Press.
10. Primrose S, Twyman R, Old B Principles of Gene Manipulation, Black well Scientific Publications, Oxford, U.K., 2001.
11. Glick, B.R. and Thompson, J.E. Methods in Plant Molecular Biology and Biotechnology, CRC
12. Press, Boxa Raton, Florida, 1993 Roberts, J. and Tucker, G.A. (eds.) Plant Hormone Protocols Humana Press, New Jersey, USA 2000.
13. Brown, T. A. (2020) Gene Cloning & DNA Analysis: An Introduction. 8thedn. UK: Wiley Blackwell.
14. Primrose, S. B. & Twyman, R.M. (2006). Principles of Gene Manipulation and Genomics. 7thedn. Victoria, Australia: Blackwell Publishing.

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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	Plant Biotechnology	
Course Code	**08/BOT/MJR/352T**	
Course Type:	MJR (Major)	
Level of the course (As per Annexure-I)	300-399	
High-Level Courses		
Course Learning Outcomes (CLO)	After completing the course: CLO1: understand concept of cellular totipotency. CLO2: learn the basics of *in vitro* cellular and developmental biology. CLO3: use various tools and techniques of plant biotechnology. 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. History of plant cell, tissue and organ culture. Applied aspects of plant tissue culture.	12
II	Concept of aseptic culture. Basic tools and techniques in plant biotechnology: sterilization of various instruments, glassware, and culture medium. Various types of culture medium. Surface sterilization of explants and aseptic inoculation. Maintenance of cultures in growth chamber. Hardening of in vitro regenerated plantlets and field transfer. Haploid culture and its applications. Germplasms conservation.	12
III	Various stages of micropropagation. Various means of micropropagation of plants: morphogenesis, organogenesis and axillary shoot activation. Somatic embryogenesis and synthetic seeds. Somaclonal variations and its applications. Physical and chemical means of protoplast isolations. Various methods of protoplast culture. Somatic hybrids and cybrids.	12
IV	*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.	12
V	Genetic engineering of plants: Vector mediated (*Agrobacterium tumefaciens*) and physical and chemical methods of gene transfer in plants.	12

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	Bt cotton and golden rice as a model system. Biotechnological invention: IPR and ethical concern.	

08/BOT/MJR/352P: Practical for Plant Biotechnology

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

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. Demonstrate ex vitro rooting.
6. Prepare synthetic seeds.
7. Design an experiment for acclimatization/hardening of in vitro regenerated plantlets.
8. Separate 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. Slater, A., Scott, N. W., & Fowler, M. W. (2012). *Plant Biotechnology: The Genetic Manipulation of Plants* (2nd ed.). Oxford University Press.
2. Gamborg, O. L., & Phillips, G. C. (Eds.). (1995). *Plant Cell, Tissue and Organ Culture: Fundamental Methods*. Springer Lab Manuals.
3. Heldt, H.-W., & Piechulla, B. (2015). *Plant Biochemistry* (4th ed.). Academic Press.
4. Altman, A., & Hasegawa, P. M. (Eds.). (2011). *Plant Biotechnology and Agriculture: Prospects for the 21st Century*. Academic Press.
5. Narayanaswamy, S. (1994). *Plant Cell and Tissue Culture*. Tata McGraw-Hill Publishing Company.
6. Pollard, J. W., & Walker, J. M. (Eds.). (1990). *Plant Cell and Tissue Culture: Methods in Molecular Biology*. Humana Press.
7. Bhojwani, S.S. Plant Tissue Culture: Application and Limitation, Elsevier Science Publishers, New York, USA, 1990.
8. Vasil, I.K. and Thorpe, T.A. Plant Cell and Tissue Culture, Kluwer Academic Publishers, The Netherlands, 1994.

Practical Books

1. Kumar, A. (2022). *A Practical Manual on Plant Biotechnology*. Rubicon Publications.
2. Hemanthakumari, B., & Shanmugam, G. (2016). *Practical Plant Biotechnology and Genetics*. Dominant Publishers.
3. Ranga, M. M., & Sharma, D. (2022). *Practical Manual Elementary Plant Biotechnology*. RLBCAU.

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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	Cell and Molecular Biology
Course Code	**08/BOT/MJR/401T**
Course Type:	MJR (Major)
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 structure and function of cells, including advanced knowledge of cell organelles, membranes, and cytoskeleton. CLO2: acquire advanced knowledge about the molecular mechanisms of DNA replication, transcription, and translation, protein sorting and PTMs in plants, and how these processes are regulated. CLO4: gain in-depth knowledge of protein sorting and PTMs in plants, and their regulation. CLO5: learn experimental design and gain practical experience in executing experiments related to plant cell and molecular biology.
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	Basic concept of Cell and Cell theory; Composition, structure and function of biomolecules (carbohydrates, lipids, proteins). Chemical foundation: Covalent and non-covalent bonds. Bioenergetics. Cell wall. Cell membrane: Dynamic structure, compositions, function, biogenesis and structural model. Plant Vacuoles: Tonoplast membrane structure and function; Cytoskeleton, organization and role of microtubules Cell junction and adhesions, Intercellular transport of endogenous macromolecules: Structure and functional significance of plasmodesmata.	12
II	The nucleus: nuclear envelope, nuclear pore complex, nucleolus. Mitochondrial and plastid biogenesis and development, concept of endosymbiosis. Organellar genome: organization and function of plastome and chondriome. Cell cycle regulation (Cyclins, CDKs), Senescence and Programmed Cell Death	12
III	Protein Sorting and Vesicle Traffic; concept of signal peptide, transport of soluble and membrane bound proteins in Endoplasmic Reticulum, ER chaperone proteins and their functions. Targeting to nucleus, mitochondria, chloroplasts, vacuoles and secretary pathway. Replication of genetic material in prokaryotes and eukaryotes. Initiation, elongation and termination.	12
IV	Prokaryotic transcription: Transcription units; RNA polymerase structure and assembly; Promotors; Initiation, elongation and termination. Eukaryotic	12

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

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	transcription: RNA polymerase structure and assembly; eukaryotic promoters and enhancers; transcription factors. Post transcriptional processing of mRNA: Capping, adenylation and Splicing, RNA editing. DNA damage and repair.	
V	Translation: Translation machinery; Ribosomes: composition and assembly. Genetic code: degeneracy of codons, initiation and termination codons, wobble hypothesis, genetic code in mitochondria; Isoaccepting tRNA Mechanism of protein synthesis: Translational factors; initiation, elongation and termination; Co- and post- translational modifications: Glycosylation, Mechanism of protein degradation.	12

08/BOT/MJR/401P: Practical for Cell and Molecular Biology

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

Laboratory Exercises

1. Demonstration of fluorescent microscope and visualization of GFP-proteins
2. Cytochemical staining of cell wall constituents.
3. Fluorescence staining of nuclei with DAPI.
4. Cell wall staining with calcofluor white.
5. Isolation of genomic DNA from plants/bacteria.
6. Amplification of genes using PCR
7. Demonstration of agarose gel electrophoresis.
8. One-dimensional SDS-PAGE protein profiling.
9. Demonstration of Southern/Northern blotting and Western Immunoblotting.
10. Gene tagging and screening
11. Techniques in cell biology: Phase contrast, Fluorescence microscopy, Laser confocal microscopy, electron microscopy (SEM, TEM), LCM (laser capture micro dissection), Flow cytometry, FACS.

Recommended Books:

1. Alberts, B., Bray, D., Lewis, J., Raff, M., Roberts, K. and Watson, J. D. 1999. Molecular Biology of the Cell.
2. Garland Publishing, Inc., New York.
3. Buchanan, B. B., Gruissem, W. and Jones, R. L. 2000. Biochemistry and Molecular Biology of Plants.
4. American Society of Plant Physiologists, Maryland, USA
5. Snustad, D. P. and Simmons, M. J. 2000. Principles of Genetics (2nd edition). John Wiley & Sons Inc., USA.
6. Nelson, D. L. and Cox, M. M. Lehninger Principles of Biochemistry (4th edition). CBS Publishers &Distributors.
7. Lewin, B. 2000. Genes VII, Oxford University Press, New York.
8. Lodish, H., Berk, A., Zipursky, S. L., Malsudaira, P., Baltimore, D. and Darnell, J. 2000.
9. Molecular Cell Biology (V Edition). W.H. Freeman and Co., New York, USA.
10. De, D. N. 2000. Plant Cell Vacuoles: An Introduction. CSIRO Publication, Collingwood, Australia.
11. Glick, B. R. and Thompson, J. E. 1993. Methods in Plant Molecular Biology and Biotechnology. CRC Press, BocaRaton, Florida.

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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	Theoretical and applied Ecology	
Course Code	**08/BOT/MJR/402T**	
Course Type:	MJR (Major)	
Level of the course (As per Annexure-I)	400-499	
Advance Courses		
Course Learning Outcomes (CLO)	After completing the course: CLO1: Understand basic ecological concepts such as ecosystem structure, population dynamics, and species interactions in a clear and practical way. CLO2: Explain how organisms interact with their environment and how these interactions shape populations, communities, and ecosystems. CLO4: Analyze ecological data and patterns like species diversity, succession, and energy flow using simple methods and real-world examples. CLO4: Apply ecological knowledge to environmental issues such as biodiversity conservation, pollution, and sustainable resource management, especially in the Indian context.	
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	Foundations of ecology: definition, scope and historical development of ecology; levels of ecological organization from organism to biosphere. The environment – physical environment, biotic environment, and biotic–abiotic interactions. Habitat and niche: habitat concept, niche theory, fundamental and realized niche, niche width and overlap, resource partitioning, and character displacement. Introductory population ecology: population characteristics and basic concepts of population growth and regulation.	12
II	Community ecology and interaction theory: species interactions – competition, herbivory, carnivory, pollination and symbiosis. Nature of ecological communities and community structure and attributes. Species diversity and its measurement. Spatial organization of communities with emphasis on edges and ecotones. Ecological succession theory – types of succession, mechanisms and the climax concept.	12
III	Ecosystem ecology: ecosystem structure and functioning, trophic organization and energy flow in ecosystems. Biogeochemical cycling (C, N, P) and ecosystem processes such as primary production and decomposition. Ecological characteristics of major ecosystems with emphasis on Indian ecosystems – forest, grassland, freshwater, marine and estuarine systems.	12
IV	Biogeography and landscape ecology: major terrestrial biomes and global distribution of ecosystems. Island biogeography theory and determinants of species richness. Biogeographical zones of India and regional biodiversity patterns. Landscape ecological perspectives on habitat heterogeneity and spatial organization of ecosystems.	12

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V	Applied ecology and conservation biology: environmental pollution and ecological consequences. Global environmental change and drivers of biodiversity loss. Biodiversity status, monitoring and documentation. Biodiversity management approaches and sustainable resource use. Principles of conservation biology with Indian conservation examples such as Project Tiger and Biosphere Reserves.	12

08/BOT/MJR/402P: Practical for Theoretical and applied Ecology

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

Laboratory/field exercises

1. Species distribution variation and distribution pattern, identifying mode of dispersion.
2. To prepare Ombrothermic diagram for different sites on the basis of given data and to comment on climate.
3. To compute phenothermal indices for some desert plants
4. To find out the relationship between two ecological variables using correlation and regression analysis.
5. To determine minimum size and number of quadrates required for reliable estimate of biomass in a natural field.
6. To find out association between important species using chi-square test.
7. To analyze plant communities using Bra-Curtis/Twin span ordination method.
9. To determine diversity indices (concentration of dominance, Shannon-Wiener, species richness, equitability and β-diversity) for protected and gochar land vegetation.
10. To estimate IVI of the species in protected and gochar land vegetation
11. To determine productivity in terrestrial (CO_2 Analyzer) and aquatic (Light and dark bottle method) systems.

Suggested Reading

1. Odum E.P., Barrett G.W. 2005. Fundamentals of Ecology. Thomson Brooks/Cole
2. Begon M., Townsend C.R., Harper J.L. 2006. Ecology: From Individuals to Ecosystems. Blackwell Publishing
3. Smith T.M., Smith R.L. 2015. Elements of Ecology. Pearson Education
4. Molles M.C. 2016. Ecology: Concepts and Applications. McGraw-Hill Education
5. Gotelli N.J. 2008. A Primer of Ecology. Sinauer Associates
6. Krebs C.J. 2014. Ecological Methods. Pearson Education
7. Colinvaux P.A. 1993. Introduction to Ecology. Wiley
8. Sharma P.D. 2018. Ecology and Environment. Rastogi Publications
9. Odum E.P., Barrett G.W. 2004. Environmental Biology. Brooks/Cole
10. Ricklefs R.E., Relyea R. 2014. The Economy of Nature. W.H. Freeman & Company
11. Lomolino M.V., Riddle B.R., Whittaker R.J. 2017. Biogeography. Sinauer Associates
12. Hunter M.L., Gibbs J.P. 2007. Conservation Biology: Foundations, Concepts, Applications. Wiley-Blackwell
13. Groom M.J., Meffe G.K., Carroll C.R. 2006. Principles of Conservation Biology. Sinauer Associates
14. Peavy H.S., Row D.R. 1984. Environmental Science and Engineering. McGraw-Hill
15. Singh J.S., Singh S.P., Gupta S.R. 2006. Indian Biodiversity: Conservation and Sustainable Use. Scientific Publishers

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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	**Advances in the Diversity of Seed Plants**	
Course Code	**08/BOT/MJR/403T**	
Course Type:	MJR (Major)	
Level of the course (As per Annexure-I)	400-499	
Advance Courses		
Course Learning Outcomes (CLO)	After completing the course: CLO1: Describe gymnosperm characters, classification, distribution in India, structure, reproduction, evolution, economic importance, and fossils. CLO2: Apply ICN principles, taxonomic hierarchy, typification, priority, and publication rules. CLO3: Compare phenetic/phylogenetic systems and merits/demerits of Bentham & Hooker, Cronquist, Takhtajan classifications. CLO4: Use herbarium methods, identification keys, floras, taxonomic evidence (morphology to DNA barcoding), GIS, and computers. CLO5: Evaluate speciation, plasticity, isolating mechanisms, endemism, hotspots, invasions, and features of angiosperm families.	
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	**Gymnosperms:** Characters and Classification, Distribution in India. General account of structure, reproduction and evolutionary relationship of Cycadales, Ginkgoales, Coniferales, Ephedrales and Gnetales. Economic importances of gymnosperm; Fossils Gymnosperms.	12
II	**Plant Taxonomy:** Principles and significance. Nomenclature: International Code of Nomenclature for algae, fungi, and plants; Taxonomic Hierarchy: Concept of species, genus, family and other categories; Typification, rules of priority, effective and valid publication.	12
III	**Angiosperm classifications:** Phenetic versus phylogenetic systems, Cladistics in taxonomy. Classification: Relative merits and demerits of major systems of classifications-Bentham and Hooker, Cronquist, Takhtajan. **Herbarium methodology:** Collection and preservation of plant specimens, World and Indian herbaria. Plant Identification: Taxonomic keys; Floras and Taxonomic Journals.	12
IV	**Taxonomic Evidence:** Morphology, Anatomy, Palynology, Embryology, Cytology, Phytochemistry, Nucleic acid hybridization as a tool in	12

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	taxonomy; DNA Barcoding. Computer applications and GIS. Evolution and differentiation of species, Phenotypic plasticity, Abrupt and gradual speciation. Isolating mechanism–Geographical, Ecological, Seasonal, Temporal, Mechanical and Ethological. Endemism, Biodiversity hotspots. Introduction and Invasion.	
V	**Floral Diversity:** Salient features of following families: Ranunculaceae, Capparidaceae Portulacaceae, Malvaceae, Zygophyllaceae, Fabaceae, Cucurbitaceae, Asteraceae, Asclepidaceae, Boraginaceae, Convolvulaceae, Acanthaceae, Lamiaceae, Nyctaginaceae, Amaranthaceae, Chenopodiaceae, Euphorbiaceae, Cyperaceae and Poaceae.	12

08/BOT/MJR/403P: Practical for Advances in the Diversity of Seed Plants

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

Laboratory Exercises

1. Comparative study of anatomy of vegetative and reproductive parts of *Cycas*, *Ginkgo*, *Cedrus*, *Abies*, *Picea*, *Cupressus*, *Araucaria*, *Taxodium*, *Podocarpus*, *Agathis*, *Taxus*, *Ephedra* and *Gnetum*.
2. Study of about 40 wild taxa representing different families and identification to species level.
3. Study of flora of the University/college campus.
4. As a part of botanical tour, student should observe and record the flora/vegetation types of the study area and submit a report at the time of practical examination.
5. Part of practical – student should submit 10 herbaria specimens/image softcopies of 10 plants of wild plant taxa.
6. Construction of taxonomic keys.
7. Demonstration of the utility of secondary metabolites in the taxonomy of some appropriate genera.
8. Comparison of different species of a genus and different genera of a family to calculate similarity coefficients and preparation of dendrograms.
9. Nomenclatural exercise.

Suggested Readings

1. Bhatnagar S. P., Moitra Alok (2003) Gymnosperms. New Age International Ltd, New Delhi
2. International Code of Nomenclature for algae, fungi, and plants (Madrid Code)
3. Angiosperm Phylogeny Group (www.apgweb).
4. Davis, P. H. and Heywood, V. A. (1973). Principles of Angiosperms Taxonomy.
5. W. F. Grant 2013. Plant Biosystematics. Academic Press, London.
6. Heywood, V. H., Brummitt, R. K., Culham, A., Seberg, O. 2007. Flowering Plant Families of the World. Firefly books Ltd, New York.
7. Heywood, V. H., Moore, D. M. 1984. Current Concepts in Plant Taxonomy. Academic Press, London.
8. Jones, S. B. and Luchsinger, A. E. 1986. Plant Systematics (Ist edition). McGraw-Hill Book Co., New York. Judd,
9. W. S., Campbell, C. S., Kellogg, E. A., Stevens, P. F. and Donoghue, M. J. 2007. Plant Systematics: A Phylogenetic Approach, 3rd ed. Sinauer.
10. Taxonomy of Vascular Plants. McMillan, New York. Naik, V. N. 1992. Taxonomy of Angiosperms. 2nd Edn. Tata McGraw Hill.
11. Nordenstam, B., El Gazaly, G. And Kassas, M. 2000. Plant Systematics for 21st Century. Portlant Press Ltd., London.
12. Pullaiah, T. 2005. Taxonomy of Angiosperms. Regency Publications, New Delhi.

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13. Radford, A. E. 1986. Fundamentals of Plant Systematics. Harper & Row Publications, USA.
14. Ravi Prasad Rao, B. 2009. Plant Name Directory. ABCD, Planographers, Hyderabad.
15. Simpson, M. G. 2006. Plant Systematics. Elseiver & Academic Press.
16. Singh, G. 2005. Plant Systematics. Oxford & IBH, New Delhi.
17. Sivarajan, V. V. 1991. Introduction to Principles of Plant Taxonomy. Oxford & IBH.
18. Solbrig, O. T. And Solbrig, D. J. 1979. Population Biology and Evolution. Addison-Wesley Publicating Co. Inc., USA.
19. Stace, C. A. 1989. Plant Taxonomy and Biosystematics. Edward Arnold Ltd., London.
20. Takhtajan, A. L. 1997. Diversity and Classification of Flowering Plants. Columbia University Press, New York.
21. Woodland, D. W. 1991. Contemporary Plant Systematics. Prentice Hall, New Jersey.

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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 Plant Development and Reproductive Biology	
Course Code	**08/BOT/MJR/451T**	
Course Type:	MJR (Major)	
Level of the course (As per Annexure-I)	400-499	
Advance Courses		
Course Learning Outcomes (CLO)	After completing the course: CLO1: Understand the physiological processes and hormonal mechanisms regulating plant growth and development. CLO2: Describe the structural and molecular aspects of plant morphogenesis, including cell differentiation and organ formation. CLO3: Explain the different modes of plant reproduction, including mechanisms of pollination, fertilization, and seed and fruit development. CLO4: Apply experimental techniques to collect, analyze, and interpret data on plant growth, development, and reproduction. CLO5: Critically evaluate scientific literature on plant development and reproduction, including the design, interpretation, and implications of research results.	
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	Introduction: Unique features of plant development. Seed germination and seedling development. Concept of stem cells in plants. Shoot apical meristem (SAM) and development of shoot; SAM molecular Biology. Cell to cell communication. Regulation of tissue differentiation with special reference to xylem and phloem, secretary ducts and laticifers. Wood development in relation to environmental factors.	12
II	Differentiation and development of Leaf. Phyllotaxy. Differentiation of epidermis (with special reference to stomata and trichomes) and mesophyll. Programmed cell death, aging and senescence. Root apical meristem (RAM) and development of root(s), lateral roots and root hairs. Cellular and molecular biology of the Quiescent Centre; Hormonal control of root development.	12
III	Reproduction: Vegetative and sexual reproduction; flower development; genetics of floral organ differentiation; homeotic mutants in Arabidopsis and Antirrhinum; sex determination in plants. Male gametophyte: microsporogenesis, role of tapetum; pollen development and gene expression; pollen germination, pollen tube growth and guidance; pollen storage; pollen allergy; pollen embryos.	12

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IV	Female gametophyte: Ovule development; megasporogenesis; organization and structure of the embryo sac. Pollination, pollen-pistil interaction, sporophytic and gametophytic self-incompatibility in plants. Double fertilization and in vitro fertilization in plants.	12
V	Endosperm development during early, maturation and desiccation stages; Embryogenesis: General and molecular pattern of development of dicot and monocot embryo; Suspensor: structure and functions; Storage proteins of endosperm and embryo; polyembryony; apomixes. Seed development. Fruit development and maturation: biochemistry and molecular biology aspects. Seed dormancy: Importance and types.	12

Laboratory/Field Exercises

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

1. Study of living shoot apices by dissections using aquatic plants such as *Ceratophyllum* and *Hydrilla*.
2. Study of cytohistological zonation in the shoot apical meristem (SAM) in sectioned and double-stained permanent slides of a suitable plant such as *Coleus*, *Kalanchoe*, tobacco. Examination of shoot apices in a monocotyledon in both T.S. and L.S. to show the origin and arrangement of leaf primordia.
3. Study of alternate and distichous, alternate and superposed, opposite and superposed; opposite and decussate leaf arrangement. Examination of rosette plants (*Launaea, Mollugo, Raphanus, Hyoscyamus*, etc.) and induction of bolting under natural conditions as well as by GA treatment.
4. Microscopic examination of vertical sections of leaves such as *Cannabis*, tobacco, *Nerium*, maize and wheat to understand the internal structure of leaf tissues and trichomes, glands, etc. Also study the C3 and C4 leaf anatomy of plants.
5. Study of epidermal peels of leaves such as *Coccinia, Gaillardia, Tradescantia, Notonea*, etc. to study the development and final structure of stomata and prepare stomatal index. Demonstration of the effectof ABA on stomatal closure.
6. Study of whole roots in monocots and dicots. Examination of L.S. of root from a permanent preparation to understand the organization of root apical meristem and its derivatives (use maize, aerial roots of banyan, *Pistia, Jussiaea*, etc.). Origin of lateral roots. Study of leguminous roots with differenttypes of nodules.
7. Study of microsporogenesis and gametogenesis in sections of anthers.
8. Examination of modes of anther dehiscence and collection of pollen grains for microscopic examination (maize, grasses, *Cannabis sativa, Crotolaria, Tradescantia, Brassica, Petunia, Solanum melongena*, etc.).
9. Tests for pollen viability using stains and *in vitro* germination. Pollen germination using hanging drop and sitting drop cultures, suspension culture and surface culture.
10. Estimating percentage and average pollen tube length *in vitro.*
11. Study of nuclear and cellular endosperm through dissections and staining.
12. Isolation of zygotic globular, heart-shaped, torpedo stage and mature embryos from suitable seeds and polyembryony in citrus, jamun (*Syzygium cumini*), etc. by dissections.
13. Study of seed dormancy and methods to break dormancy.

Suggested Readings

1. Atwell, B. J., Kriedemann, P. E., & Turnbull, C. G. N. (Eds.). (1999). *Plants in action: Adaptation in nature, performance in cultivation*. Macmillan Education.
2. Bhojwani, S. S., & Bhatnagar, S. P. (2000). *The embryology of angiosperms* (4th rev. ed.). Vikas Publishing House.

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3. Burgess, J. (1985). *An introduction to plant cell development*. Cambridge University Press.
4. Fagri, K., & van der Pijl, L. (1979). *The principles of pollination ecology* (3rd ed.). Pergamon Press.
5. Fahn, A. (1982). *Plant anatomy* (3rd ed.). Pergamon Press.
6. Fosket, D. E. (1994). *Plant growth and development: A molecular approach*. Academic Press.
7. Howell, S. H. (1998). *Molecular and cellular biology of plant development*. Cambridge University Press.
   Leins, P., Tucker, S. C., & Endress, P. K. (Eds.). (1988). *Aspects of floral development*. J. Cramer.
8. Raghavan, V. (1997). *Molecular embryology of flowering plants*. Cambridge University Press.
9. Raghavan, V. (2000). *Developmental biology of flowering plants*. Springer.
   Shivanna, K. R., & Rangaswamy, N. S. (1992). *Pollen biology: A laboratory manual*. Springer-Verlag.
10. Steeves, T. A., & Sussex, I. M. (1989). *Patterns in plant development* (2nd ed.). Cambridge University Press.
11. Waisel, Y., Eshel, A., & Kafkafi, U. (Eds.). (1996). *Plant roots: The hidden half* (2nd ed.). Marcel Dekker.
    (Note: Corrected year and title phrasing.)
12. Davies, P. J. (Ed.). (2010). *Plant hormones: Biosynthesis, signal transduction, action!* (3rd ed.). Springer.
    (Essential for hormonal regulation in CLO1.)
13. Evert, R. F., & Eichhorn, S. E. (2013). *Raven biology of plants* (8th ed.). W.H. Freeman.
    (Updated standard for morphology and development; ISBN: 978-1429219617.)
14. Johri, B. M., Ambegaokar, K. B., & Srivastava, P. S. (2011). *Comparative embryology of angiosperms* (Vol. 1 & 2). Springer.
    (Modern embryology complement to Bhojwani; ISBN: 978-3642636022.)
15. Maheswari, P. (2019). *An introduction to embryology of angiosperms* (Reprint ed.). Agrobios India.
    Taiz, L., Zeiger, E., Møller, I. M., & Murphy, A. (2015). *Plant physiology and development* (6th ed.). Sinauer Associates.

Suggested Readings (Laboratory Exercises)

16. Chopra, V. L. (2001). *Plant breeding: Field crops*. Oxford & IBH Publishing.
17. Chopra, V. L. (2001). *Plant breeding: Theory and practice*. Oxford & IBH Publishing.
18. Shivanna, K. R., & Rangaswamy, N. S. (1992). *Pollen biology: A laboratory manual*. Springer-Verlag.
19. Johansen, D. A. (2018). *Plant embryology: Embryogenesis, tissue culture and experiments in plants* (Monograph ed.). Agri Horti.
    (Practical guide for CLO3/CLO4; ISBN: 978-9386287571.)

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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 Plant Physiology and Metabolism	
Course Code	**08/BOT/MJR/452T**	
Course Type:	MJR (Major)	
Level of the course (As per Annexure-I)	400-499	
Advance Courses		
Course Learning Outcomes (CLO)	After completing the course: CLO1: Learn about membrane transport, water/solute translocation, and nutrient uptake mechanisms in plants. CLO2: Gain knowledge of photosynthesis, including light reactions, carbon fixation pathways, and photorespiration. CLO3: Learn about plant signal transduction and growth regulators, including hormones and environmental cues. CLO4: Gain knowledge of mechanisms in plant responses to abiotic and biotic stresses, including drought, salinity, and pathogens. CLO5: Develop skills in applying techniques for studying plant physiology, including biochemical and physiological assays.	
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	Membrane transport and Translocation of water and solutes: Mechanism of water transport through xylem, stomatal regulation, nutrient deficiency, root microbe interactions in facilitating nutrient uptake, phloem loading and unloading, passive and active solute transport, Protein transporters. Aquaporin, ABC Transpoter.	12
II	Photosynthesis: Photosynthetic apparatus, photosynthetic pigments and light harvesting complexes, photooxidation of water, mechanisms of electron and proton transport, carbon assimilation the Calvin cycle, photo respiration and its significance, the C4 cycle, the CAM pathway, CO_2 Concentrating mechanism in plants. Light regulation of C3 and C4 cycle enzymes.	12
III	Signal transduction: Overview, receptors, signaling molecules, G-proteins, Tyrosine kinase, phospholipids signaling, role of cyclic nucleotides, calcium-calmodulin cascade, and phosphatases, specific signaling mechanisms, e.g. two- component sensor-regulator system in bacteria and plants. Sensory photo receptors.	12
IV	Plant growth regulators: Physiological effects and general mechanism of action of plant hormones. Brief account on brassinosteroids, polyamines, Jasmonic acid, salicylic acid and nitric oxide (NO). Photoperiodism and	12

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	its significance, endogenous clock and its regulation. Vernalization. Genetic regulation of flowering	
V	Stress physiology- Plant responses to biotic and abiotic stress, general mechanisms of abiotic stress tolerance, drought and salinity stress, freezing and heat stress, heavy metals and phytochelatins.	12

Laboratory exercise

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

1. Extraction of chloroplast pigments from leaves and preparation of the absorption spectrum ofchlorophylls and carotenoids.
2. To determine the chlorophyll a/chlorophyll b ratio in C3 and C4 plants.
3. Desalting of proteins by gel filtration chromatography employing Sephadex G25.
4. SDS PAGE for soluble proteins extracted from the given plant materials and comparison oftheir profile by staining with Coomassie Brilliant Blue or silver nitrate.
5. Isolation of intact chloroplasts and estimation of chloroplast proteins by spot protein assay.
6. To demonstrate photophosphorylation in intact chloroplasts, resolve the phosphoproteins by SDS-PAGEand perform autoradiography.
7. Radioisotope methodology, autoradiography, instrumentation (GM counter and Scintillationcounter) and principals involved.
8. Estimation of proline content in given samples.
9. Assay the activity of antioxidant enzymes in given plant samples.

Suggested Reading

1. Ahmad, P. and Wani, M.R. 2014. Physiological Mechanisms and Adaptation Strategies in Plants UnderChanging Environment (eds). Springer New York
2. Buchanan, B. B., Gruissem, W. and Jones, R. L. 2000. Biochemistry and Molecular Biology of Plants.American Society of Plant Physiologists. Maryland, USA.
3. Dennis, D. T., Turpin, D. H., Lefebvre, D. D. and Layzell, D. B. (eds) 1997. Plant Metabolism (2ndedition).Longman, Essex, England.
4. Galston, A. W. 1989. Life Processes in Plants. Scientific American Library, Springer Verlag, New York, USA.
5. Hooykaas, P. J. J., Hall, M. A. and Libbenga, K. R. (eds) 1999. Biochemistry and Molecular Biology ofPlant Hormones. Elsevier, Amsterdam, The Netherlands.
6. Hopkins, W. G. 1995. Introduction to Plant Physiology. John Wiley & Sons, Inc., New York, USA. Hopkins, W.G. and Huner, N.P.A . 2009. Introduction to Plant Physiology (4th Edition). John Wiley &Sons, Inc. New York, USA
7. Lodish, H., Berk, A., Zipursky, S.L., Matsudaira, P., Baltimore, D. and Darnell, J. 2000. Molecular Cell Biology (4th edition). W.H. Freeman and Company, New York, USA.
8. Moore, T. C. 1989. Biochemistry and Physiology of Plant Hormones (2nd edition). Springer Verlag, New York, USA.
9. Nobel, P. S. 1999. Physiochemical and Environmental Plant Physiology (2nd edition). Academic Press, SanDiego, USA.
10. Ricardo, A. 2012. Plant Responses to Drought Stress - From Morphological to Molecular Features (ed). Springer
11. Salisbury, F. B. and Ross, C. W. 1992. Plant Physiology (4th edition). Wadsworth Publishing Co., California,USA.
12. Singhal, G. S., Renger, G., Sopory, S. K., Irrgang, K. D. and Govindjee. 1999. Concepts in Photobiology: Photosynthesis and Photomorphogenesis. Narosa Publishing House. New Delhi.
13. Taiz, L. and Zeiger, E. 1998. Plant Physiology (2nd edition). Sinauer Associates, Inc.,

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Publishers,Massachusetts, USA.
1. Tripathi, B.N. and, Müller, M.2015.Stress Responses in Plants: Mechanisms of Toxicity and Tolerance (eds). Springer
2. Thomas, B. and Vince Prue, D. 1997. Photoperiodism in Plants (2nd edition). Academic Press, San Diego,USA.
3. Westhoff, P. 1998. Molecular Plant Development: from Gene to Plant. Oxford University Press, Oxford,UK.

Suggested Readings (For Laboratory Exercises)

4. Bajracharya, D. 1999. Experiments in Plant Physiology: A Laboratory „Manual. Narosa Publishing House, New Delhi.
5. Cooper, T. G. 1977. Tools in Biochemistry. John Wiley, New York, USA.
6. Copeland, R. A. 1996. Enzymes: A Practical Introduction to Structure, Mechanism, and Data Analysis.VCHPublishers, New York.
7. Dennison, C. 1999. A Guide to Protein Isolation. Kluwer Academic Publishers, Dordrecht, The Netherland. Devi, P. 2000. Principles and Methods of Plant Molecular Biology, Biochemistry and Genetics. Agrobios, Jodhpur, India.
8. Dryer, R. L. and Lata, G. F. 1989. Experimental Biochemistry. Oxford University Press, New York. Harborne, T. C. 1981. Phytochernical Methods: A Guide to Modern Techniques of Plant Analysis.Chapman& Hall, London.
9. Harries, B. D. (Ed.) 1998. Gel Electrophoresis of Proteins: A Practical Approach, 3rd edition. PAS, OxfordUniversity Press, Oxford, U.K.
10. Moore, T. C. 1974. Research Experiences in Plant Physiology: A Laboratory Manual. Springer Verlag, Berlin.
11. Ninfa, A. J. and Ballou, D. P. 1998. Fundamental Laboratory Approaches for Biochemistry and Biotechnology. Fitzgerald Science Press, Inc., Maryland, USA.
12. Plummer, D. T. 1988. An Introduction to Practical Biochemistry. Tata McGraw Hill Publishing Co. Ltd., New Delhi.
13. Scott, R. P. W. 1995. Techniques and Practice of Chromatography. Marcel Dekker, Inc., New York. Wilson, K. and Goulding, K. H. (eds.), 1986. A Biologists Guide to Principles and Techniques of Practical Biochemistry. Edward Arnold, London, UK.
14. Wilson, K. and Walker, J. 1994. Practical Biochemistry: Principles and Techniques, 4th edition. CambridgeUniversity Press, Cambridge, UK.

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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.
- The maximum intake of the department for Honours with Research programme is fixed by

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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.

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