Department of Botany
Nagaland University
Lumami 798 627

M. Sc. Syllabus-2025
(Approved by 40th Academic Council Meeting held on 23rd May 2025)

The M. Sc. (Botany) programme of the University comprises of four Semesters spread over a period of two years. Students would be required to earn **84 Credits** for award of M. Sc. (Botany) degree. The credits earned shall have a minimum of **77 credits** by way of **core courses** offered by the Department and **7 credits** by way of **Choice Based Credit Paper** offered by the Department. The Department shall announce the choice base credit system (**CBCS)** courses available in the semester. The students shall convey in writing to the Department at the start of the session, the name of the CBCS course they would be registering for. Besides 82 Credits, student each student needs to earn **2 Credits through MOOCS Courses during the duration of M. Sc. courses and score will be reflected in the 4th Semester mark sheet.**

The M.Sc. Degree programme in Botany shall comprise of 10 core courses through regular classroom teaching spread over four semesters. Each core course shall comprise of one theory paper worth 4 credits (100 marks) and corresponding practical + Tutorial/Mentoring worth 2+1 credits (50 marks). Students shall be evaluated by way of continuous assessment (internal tests, seminar, assignment) comprising 25% of credit value (both theory and practical papers). The duration of end semester examination for theory papers shall be 3 hours and practical papers 4 hours. As a part of Choice Based Credit Papers, students need to opt for ONE theory paper (4 credits) and corresponding practical + Tutorial/Mentoring (2+1 credits) in the 4th semester from the list provided (details given below and the Department will notify the courses available in the semester. Further, each student will have to undertake a project work for 200 marks (8 credits) from the list given in the content page. The project work will be allotted in the third semester and project report will have to be submitted and evaluated at the end of the fourth semester. Of the 8 credits, 2 credit each will be on presentation of the project reports and 6 credits for project report/dissertation. Students need to undertake internship for 100 marks (4 credits) as per university guidelines.

There will be two internal assessment tests per paper (both theory and practical separately) and student must appear in both tests failing which he/she will not be allowed to write the end Semester examination. Besides internal tests, in every semester each student need to present one Seminar (mandatory) on a topic given to them which will carry 20 marks. In internal assessment tests a student must score a minimum of 40% marks to qualify for the end Semester examination. Each student must attend at least 75% of the classes in individual paper failing which students will not be allowed to write the end Semester examination.

In the beginning of each paper, the course objectives, expected outcome and scope of employment from the paper are given in brief.

Expected Programme Outcomes

- *Students are expected to learn about the basics of lower plants and their importance.*
- *Important aspects of plant pathology such as diseases caused by fungi, bacteria and viruses and defence mechanisms will be dealt with suitable details for the benefit of the students.*
- *Students will learn about the diversity of flowering plants and their different systems of classifications.*
- *To inspire students to understand the anatomy, embryology and palynology of angiosperms.*
- *Will gain knowledge about some important aspects of biochemistry, biosynthetic and metabolic pathways, plant metabolism, factors affecting plant growths etc.*
- *Different aspects of cell biology/cytology including plant cell structure, components and functions; different aspects of genetics and plant breeding will be learnt by the students.*
- *Different biological processes at molecular level and different modern techniques in the field of biotechnology with reference to plants with hands on training will be provided.*
- *On completion of the course students will have the expertise in Bioprospecting, test various physico-chemical properties of water and soil, qualitative and quantitative mapping of resources which would help in creating employability in various institutes/centres related in the field of Environment and Forest, Government and NGO's dealing with Biodiversity and Sustainable livelihood. It will also help encourage Bio- entrepreneurship.*
- *Introduction to basic statistical tools for biological research and data analysis. Awareness of climate change and to provide exposure on resilience of species in nature*
- *The students will also learn about phylogenetic tree and phenetic approach to classification along with scope and concept of biosystematics.*

Programme Specific Outcomes

- *Students will be able to handle equipments for analytical techniques with regards to soil and water quality assessments. Techniques such as Spectrophotometry, Nitrogen analyzer, Flame photometer, Digital herbarium.*
- *Students will learn techniques of fungal and bacterial isolation and its culture. Students can identify the pathogen and its associated plant diseases.*
- *Students will be capable to perform various experiments related to 'Plant Tissue Culture, Molecular characterization, Phytochemical analysis, Molecular biology, Biotechnology and other Applied Plant Science' as they will be trained to handle different equipments like PCR, Different Gel Imaging Systems , UPLC, Electrophoresis Systems, Biosafety Cabinet, Laminar Flow Cabinet, Deep Freezers, Different types of Autoclaves, Ultra Water Purifier, Refrigerated Centrifuge, Muffle Furnace and other modern equipments necessary for modern days research.*
- *Student will undertake a small research topic as a part of M Sc. Dissertation and will execute in two semesters. The purpose of the assignment is to ignite the analytic approach of the students and mentally prepare as a potential future researcher. Further, students will be allowed for 'Industrial Visit, National Research Laboratories of their choice for a short duration or 'Academic Study Tour' as per the University rule.*

Courses Having Scope for Employability/Entrepreneurship/Skill Development

Course No.	Course Title	Activities having direct bearing on employability/entrepreneurship/skill development
BOT(T)-103(C)	Experimental Microbiology	This course may create employability in various entrepreneurship by way of executing mushroom cultivation, fermentation technology and identifying plant diseases in agricultural/horticultural sector.
BOT(P) -203C)	Plant Biochemistry and Physiology	This paper deals with the different aspects of plant biochemistry and plant molecular biology. Students will gain knowledge about some important aspects of biochemistry, biosynthetic and metabolic pathways, plant metabolism, and molecular biology etc. The knowledge so gathered in this paper can be utilized in the subsequent semesters/papers. Efforts are being made to accommodate most of the important aspects of plant biochemistry and physiology which can be helpful of students to prepare for employment in 'Biochemical and molecular biology industries and related Government and private sectors.
BOT(T)-404(CBCP)	Biodiversity Conservation and Ecosystem Analysis	On completion of the course, students will expertise in analytical skills of various physico-chemical parameters of water and soil, qualitative and quantitative mapping of b i o resources which would help in creating employability in various Institutes/Centres related in the field of Environment and Forest, Government and NGO's dealing with Biodiversity and Sustainable livelihood. It will also help encourage Bio-entrepreneurship.
BOT(T)-305(C)	Plant and Environmental Biotechnology	Use of different emerging technologies/tools in biological science is necessary for human welfare. This paper deals with different biological processes at molecular level and different modern techniques in the field of plant biotechnology and environmental biotechnology. This paper will help in getting employment in 'Plant Tissue Culture Industry/Lab, Biotechnology Industry/Lab and Environmental Biotechnology, Faculties/ Scientists in the Colleges/University/Research Institutes. Further, the students can start their own entrepreneurship unit/Startup.
BOT(T)- 408(CBCP)	Plant Biotechnology	Use of different emerging technologies/tools in biological science is necessary for human welfare. This paper deals with different biological processes at molecular level and different modern techniques in the field of biotechnology with reference to plants. This paper will help in getting employment in 'Plant Tissue Culture Industry/Lab, Biotechnology Industry/Lab, Faculties/ Scientists in the Colleges/University/Research Institutes. Further, the students can start their own entrepreneurship unit/Startup.

Courses Contents

Students with 3 years UG can take admission.

Sem.	Course Code	Course Title	Course Type	Max. Marks	Credits	Page No.
I	BOT(T)-101(C)	Biology and Diversity of Lower Plants	Theory	100	4	
	BOT(P)-102(C)	Biology and Diversity of Lower Plants (Practical) + Tutorial/Mentoring	Practical	50	2 + 1	
	BOT(T)-103(C)	Applied Microbiology	Theory	100	4	
	BOT(P)-104(C)	Applied Microbiology (Practical) + Tutorial/Mentoring	Practical	50	2 + 1	
	BOT(T)-105(C)	Angiosperms Taxonomy and Economic Botany	Theory	100	4	
	BOT(P)-106(C)	Angiosperms Taxonomy and Economic Botany (Practical) + Tutorial/Mentoring	Practical	50	2 + 1	
			Total	450	21	
II	BOT(T)-201(C)	Gymnosperms, Anatomy, Reproductive Biology and Embryology	Theory	100	4	
	BOT(P)-202(C)	Gymnosperms, Anatomy, Reproductive Biology and Embryology (Practical) + Tutorial/Mentoring	Practical	50	2 + 1	
	BOT(T)-203(C)	Plant Biochemistry and Physiology	Theory	100	4	
	BOT(P)-204(C)	Plant Biochemistry and Physiology (Practical) + Tutorial/Mentoring	Practical	50	2 + 1	
	BOT(T)-205(C)	Environment, Biodiversity and Biostatistics	Theory	100	4	
	BOT(P)-206(C)	Environment, Biodiversity and Biostatistics (Practical) + Tutorial/Mentoring	Practical	50	2 + 1	
			Total	450	21	
		Students can exit after1 year with PG Diploma	**(Exit)**			
(Intake)		***4 years UG can have lateral entry (1 yr. PG)***				
III	BOT(T)-301(C)	Molecular Biology and Cytogenetics	Theory	100	4	
	BOT(P)-302(C)	Molecular Biology and Cytogenetics (Practical) + Tutorial/Mentoring	Practical	50	2 + 1	
	BOT(T)-303(C)	Plant Diversity, Ecology and Ecosystem Studies	Theory	100	4	
	BOT(P)-304(C)	Plant Diversity, Ecology and Ecosystem Studies (Practical) + Tutorial/Mentoring	Practical	50	2 + 1	
	BOT(T)-305(C)	Plant and Environmental Biotechnology	Theory	100	4	
	BOT(P)-306(C)	Plant and Environmental Biotechnology (Practical) + Tutorial/Mentoring	Practical	50	2 + 1	
	BOT(T)-307(C)	MOOCS (Value Added Course)	Online	-	2	
			Total	450	23	
IV	BOT(T)-401(C)	Project + Internship	Practical	200+100	8+4	
	BOT(T)-402(CBCP)	*Angiosperm Taxonomy & Biosystematics*	Theory	100	4	
	BOT(P)-403(CBCP)	*Angiosperm Taxonomy & Biosystematics* (Practical) + Tutorial/Mentoring	Practical	50	2 + 1	
	BOT(T)-404(CBCP)	*Biodiversity Conservation and Ecosystem Analysis*	Theory	100	4	
	BOT(P)-405(CBCP)	*Biodiversity Conservation and Ecosystem Analysis* (Practical) + Tutorial/Mentoring	Practical	50	2 + 1	
	BOT(T)-406(CBCP)	*Microbial Studies*	Theory	100	4	
	BOT(P)-407(CBCP)	*Microbial Studies* (Practical) + Tutorial/Mentoring	Practical	50	2 + 1	
	BOT(T)-408(CBCP)	*Plant Biotechnology*	Theory	100	4	
	BOT(P)-409(CBCP)	*Plant Biotechnology* (Practical) + Tutorial/Mentoring	Practical	50	2 + 1	
	BOT(T)-410(CBCP)	*Plant Stress Physiology*	Theory	100	4	
	BOT(P)-411(CBCP)	*Plant Stress Physiology* (Practical) + Tutorial/Mentoring	Practical	50	2 + 1	
	BOT(T)-412(CBCP)	*Microbial Applications in Agriculture and Environment*	Theory	100	4	
	BOT(P)-413(CBCP)	*Microbial Applications in Agriculture and Environment* (Practical) + Tutorial	Practical	50	2 + 1	
	BOT(T)-414(CBCP)	*Reproductive Biology of Angiosperms*	Theory	100	4	
	BOT(P)-415(CBCP)	*Reproductive Biology of Angiosperms* (Practical) + Tutorial/Mentoring	Practical	50	2 + 1	
			Total	450	19	
			Grand Total	1800	84	

- Abbreviations: BOT(T): Botany Theory, BOT(P): Botany Practical, C: Core; CBCP: Choice Based Credit Paper, MOOCS (Massive Open Online Course)
- A student will choose/start the research project from 3rd semester.
- The student distribution for research project will be done at the end of second semester.
- Broad areas of Project Work: Higher Plant Ecology, Biodiversity Conservation & Ecosystem analysis (Aquatic and terrestrial ecosystem), Phytogeography, Microbial Ecology, Applied Microbiology, Food Fermentation, Plant Molecular Biology, Plant Physiology, Reproductive Biology, Seed Biology, Plant Biotechnology, Plant Genetics & Cytogenetics, Angiosperm Taxonomy, Ethnobotany, Lower plant etc.
- Students need to opt for one of the CBCS paper and its corresponding practical from the list given above.
- Credit earned from SWAYAM not related to subject will be considered as Value Added Courses.

BOT(T) - 101(C): Biology and Diversity of Lower Plants (4 Credits)

Objectives: The paper introduces about the diversity of lower plants viz., Algae, Bryophytes, Lichens and Pteridophytes. It also contains topics on classification, distribution, cellular structure and various beneficial products of these lower plants. The ecological importance of this group of plants is also presented.

Unit - I

Important systems for algal classification with the employed criteria; types of life-cycles; pigment constitution; different chloroplast structure. Nature of cell wall components; food reserves; diagnostic characters of major algal divisions; Prochlorophyta, Chlorophyta, Charophyta, Xanthophyta, Bacillariophyta, Phaeophyta and Rhodophyta.

Unit - II

Algae in diversified habitats (terrestrial, freshwater, marine); nitrogen fixation by blue-green algae; industrial uses of algae; toxic algae; biofertilizer; water bloom; algae as indicators of pollution; Symbiotic algal association.

Unit - III

Origin and classification of bryophytes; general account of gametophyte and sporophyte; evolution of sporophytes; vegetative and sexual reproduction; economic and ecological importance; a general account of lichens with particular reference to their mode of life and structure, classification, economic and ecological importance.

Unit - IV

Origin and classification of pteridophytes; Comparative account of morphology, anatomy and reproduction; general account of Psilophytopsida, Psilotopsida, Lycopsida, Sphenopsida and Pteropsida; Telome theory; Economic importance.

Suggested Readings

1. Kumar, H. D. (1988). Introductory Phycology. Aff. E.W. Press Ltd. New Delhi.
2. Chapman, V. J., Chapman, D. J., (1973). The Algae. Mc Millan.
3. Fritsch, F.E. (1935 & 1945). Structure and Reproduction of Algae. Vol I and II. Camb. Univ. Press.
4. Lee, F. R. (1980). Phycology. Camb. Univ. Press.
5. Round, F. E. (1986). The Biology of Algae. Camb. Univ. Press.
6. Morris, I (1986). An Introduction to Algae. Camb. Univ. Press.
7. Parihar, N. S. (1991). An Introduction to Embryophyta. Vol I-Bryophyta. Central Book Depot.
8. Puri, P. (1980). Bryophyta. Atma Rams & Sons.
9. Watson, E. V. (1971). The Structure and Life of Bryophytes. Hutchinson Univ. Library.
10. Schofield, W. B. (1985). Introduction to Bryology. Mc Millan.
11. Smith, G. M. (1955). Cryptogamic Botany. Vol II-Bryophytes and Pteridophytes. Mc Graw Hill.
12. Sporne, K. R. (1991). The Morphology of Pteridophytes. B.I. Pub. Pvt. Ltd. Bombay.
13. Parihar, N. S. (1996). Biology and Morphology of Pteridophytes. Central Book Depot, Allahabad.

BOT(P) - 102(C): Biology and Diversity of Lower Plants (3 Credits)

1. Algae: Collection, identification and study of morphological and reproductive features of common Indian freshwater marine algae.
2. Bryophytes: Study of morphology, anatomy and reproductive structures of Bryophytes.
3. Study of morphology, anatomy and reproductive structures of locally available forms belonging to various groups of pteridophytes.
4. Study of some extinct Pteridophytes with the help of fossil specimens/slides.

Suggested Readings: Same as in BOT(T) - 101(C).

BOT(T) - 103(C): Applied Microbiology (4 Credits)

Objectives: Important aspects of plant pathology such as diseases caused by fungi, bacteria and viruses and defense mechanisms will be dealt with suitable details for the benefit of the students. These topics will enrich the background of those who wish to study Plant Pathology intensively. Ecology of microorganisms specially soil, air and microbial interactions, fermentation, food and dairy, antigen-antibody interactions will be discussed in detail.

Unit - I

Recent trends and criteria used in the classification of fungi with reference to vegetative and reproductive structures; Life cycle of fungi; Mushroom cultivation; Rhizosphere mycoflora; Fungi in bioremediation.

Unit - II

Symptomology and identification of plant diseases with reference to fungi, bacteria and viruses; Role of enzymes and toxins in pathogenesis; Effect of temperature, pH and moisture on the development of plant diseases; Biological control of plant diseases.

Unit - III

Microbiology of soil; Microorganisms found in food, food spoilage and food poisoning; Fermentation and food preservation; Role of microbes in industries with reference to production of alcohol and organic acids; Antigens and antibodies; Antibiotics; Bio-fertilizers; Role of microbes in phosphorus and nitrogen cycles.

Unit - IV

Various nutritional forms of microorganisms; Defense mechanisms; Resistant variety; Plant quarantine; Different types of mycorrhizal associations and their application in forestry and agriculture.

Suggested Readings

1. Alexander, M (1979). Advances in Microbial Ecology, Plenum Press.
2. Alexopolous, C. J and Mirus, C. W (1983). Introductory Mycology: Wiley Eastern.
3. Atlas, R. M and Bartha, R (1997). 4th Edition. Microbial Ecology: Fundamental applications. Benjamin/Cummings Science Pub.
4. Blakeman, J. P and Williamson, B. (1994). Ecology of plant pathogens. CAB. International.
5. Creager, J. G., Black, G and Davidson, V. E. (1990). Microbiology: Principles and Applications. Prentice Hall.
6. George, N. A (1988). Plant Pathology (3rd Edition). Academic Press.
7. Harley, H. L and Smith, S. E. (1983). Mycorrhizal Symbiosis. Academic Press.
8. Mehrotra, R. S (1995). Plant Pathology. Tata Mc Graw Hill.
9. Michael, J., Carlile, S., Watkinson C and Gooday, G. W. (1994). The Fungi (2nd Edition) Academic Press.
10. Dubey, R. C and Maheshwari, D. K. (2009). Text book of Microbiology. Revised edition 2005, reprint 2009. S. Chand and Company Ltd. New Delhi.
11. Sharma, P. D. (1998). Microbiology and Plant Pathology. Rastogi Publications.

BOT(P) - 104(C): Applied Microbiology (3 Credits)

1. Collection and identification causal organisms from the diseased plant material.
2. Sauerkraut preparation (fermentation)
3. Preparation of media for culture of microorganisms.
4. Isolation and enumeration of microorganisms from soil air and litter.
5. Measurement of growth and calculation of microbial population
6. Isolation of pure and axenic culture
7. Gram staining of bacteria
8. Study of different mycorrhizal association.

Suggested Readings: As in BOT(T) - 103(C).

BOT(T) - 105(C): Angiosperms Taxonomy and Economic Botany (4 Credits)

Objectives: In this course the student learns about the diversity of flowering plants and their different systems of classifications. A clear picture of plant nomenclature is also presented to the learners. The student is also expected to learn about the recent trends employed in solving taxonomic problems. The ecological importance of plants is also emphasized.

Unit - I

Plant taxonomy and its concept: components and approaches of systematics; taxonomic hierarchy, units of classification up to intra-specific level, systems of plant classification, artificial, natural and phylogenetic, merits and demerits of the major systems of the classification; brief account of angiosperm phylogeny group (AGP IV), merits and demerits of AGP; Herbarium methods and functions.

Unit - II

Plant Nomenclature: Polynomial, binomial, broad outline of the latest ICN; Major roles, rank of taxa, type method and typification, role of priority and its limitations, effective and valid publication, retention, choice and rejection of names; Definitions, legitimate and illegitimate names, synonyms, basionyms, superfluous names, nomen nudum, later homonym, tautonym; names of hybrids and cultivable plants, nomina conservanda.

Unit - III

Sources of Taxonomic Evidences: Embryology, palynology, vegetative and reproductive anatomy, cytotaxonomy; Plant geography and Ecology; Origin of angiosperms, time and place of origin; general principles of angiosperm phylogeny.

Unit - IV

Economic Botany: general account of ethnobotany; holistic approach to man and plant relationship; economic importance of plants with special reference to North East India; medicinal, timber, vegetable, fibre, fruit yielding plants of North East India. A general account of spices and condiments, essential oils, cereals, beverage yielding plants.

Suggested Readings

1. *Angiosperm Phylogeny Group (2016), "An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants: APG IV",* Botanical Journal of the Linnean Society*, 181 (1): 1–20,* doi:10.1111/boj.12385
2. Davis, P.H. and Heywood, V.H. 1973. Principles of Angiosperms Taxonomy. Robert E. Kreiger Pub. Co., New York.
3. Grant, W.F. 1984. Plant Biosystematics. Academic Press, London.
4. Harrison, H.J. 1971. New Concepts in Flowering Plant Taxonomy. Nieman Educational Books Ltd., London.
5. Heslop-Harrison, J. 1967. Plant Taxonomy. English Language Book Soc. & Edward Arnold Pub. Ltd., UK.

6. Heywood, V.H. and Moore, D.M. 1984. Current Concepts in Plant Taxonomy. Academic Press, London.
7. Jain, S.K. 1981. Glimpses of Indian Ethnobotany. Oxford and IPH.
8. Jain, S. K. and Rao, R.R. 1977. A Handbook of Field and Herbarium Methods. Today and Tomorrow.
9. Judd, Walter S.; Campbell, Christopher S.; Stevens, Peter F.; and Donoghue, Michael J., "Plant Systematics: A Phylogenetic Approach" (2008). Faculty and Staff Monograph Publications. 76. https://digitalcommons.library.umaine.edu/fac_monographs/76
10. Mondal, A. K. 2011. Advanced Plant Taxonomy. New Central Book Agency, Kolkotta.
11. Naik, V. N. 1990. Introductory Plant Taxonomy. Longman.
12. Nordenstam, B., El Gazaly, G. and Kassas, M. 2000. Plant Systematics for 21st Century. Portlant Press Ltd., London.
13. Radford, A.E. 1986. Fundamentals of Plant Systematics. Harper & Row Publications, USA.
14. Sivaranjan, V. V. 1990. Introduction to Principles of Plant Taxonomy. Oxford and IBH.
15. Stace, C.A. 1989. Plant Taxonomy and Biosystematics (2nd edition). Edward Arnold Ltd., London.Takhtajan, A.L. 1997.
16. Diversity and Classification of Flowering Plants. Columbia University Press, New York.
17. Verma, B. K. 2011. Introduction to Taxonomy of Angiosperms. PHI Learning Pvt. Ltd., New Delhi.
18. Woodland, D.W. 1991. Contemporary Plant Systematics. Prentice Hall, New Jersey.

BOT(P) - 106(C): Angiosperm Taxonomy and Economic Botany (3 Credits)

1. Study of taxonomic terminologies with the locally available plants.
2. Study of flowering plants with their analytical drawings, descriptions and identification up to species.
3. Preparation method for herbarium specimens and their submissions.
4. Preparation method for museum specimens and their submissions.
5. Practical handling of floras and manuals for identification of plants.
6. Local Field Tour (subject to grant of funds).

Suggested Reading is same as in BOT(T) -105(C)

BOT(T) - 201(C): Gymnosperm, Anatomy, Reproductive Biology and Embryology (4 Credits)

Objectives: To study and impart knowledge about the occurrence, distribution, structure and life history of Gymnosperms, Angiosperms and fossil plants. To inspire students to understand the anatomy, embryology and palynology of angiosperms.

UNIT - I

Principles of palaeobotany, Fossilization: Process, types, methods of preservation. Geological time scale and importance of fossil plants. General characters and classification of gymnosperms. Comparative account of sporophyte and gametophyte of Cycadales, Ginkgoales, Coniferales and Gnetales. General account of Pteridospermales, Pentoxylales and Cordaitales. Economic importance of gymnosperms.

UNIT - II

Shoot apical meristem (SAM); Types and phylogeny of stomata; Types of nodal anatomy, Types of cambium, Seed anatomy of monocotyledonous and dicotyledonous seeds, Vascular tissue differentiation- Xylem and phloem. Primary and secondary growth: stem and root. Secretory tissues: types and functions.

UNIT - III

Pollen fertility and male sterility; Incompatibility types and methods of overcoming incompatibilities; Fertilization, syngamy and triple fusion, Endosperm types and their development, endosperm haustoria and their function.

UNIT - IV

Microsporangium – Structure and function of wall layers, Microsporogenesis, Ovule: structure and types, Megasporogenesis, Embryosac types, Ultrastructure of mature embryosac, synergid and antipodal haustoria; Structure, cytology and function of suspensor.

Suggested Readings

1. Bhojwani, S.S. and Bhatnagar, S.P. 2000. The embryology of angiosperms (4th revised and enlarged edition) Vikas Publishing house, New Delhi.
2. Chaturvedi, S.K. and Shonali Chaturvedi, 2001. Biology of reproduction in angiosperms. Bioved research society, Allahabad
3. Ravan, P.H., Evert, R.F. and eichhom, S.E. 1992. Biology of flowering plants. Cambridge University Press, Cambridge.
4. Raghavan, V. 1999. Developmental biology of flowering plants. Springer – Verlag, New York.
5. Sattler, R. (Ed.) 1978. Theoretical plant morphology. Leiden Univ. Press.
6. Sporne, K.R. 1974. The morphology of angiosperms. Hutchinsons Univ. Press

7. Meeuse, A.D.J. 1966. Fundamentals of phytomorphology. Ronald Press Company.
8. Maheshwari, P. 1950. An introduction to the embryology of angiosperms. Mcgraw Hill Book Co.
9. Pandey, A.K. 1997. Embryology of angiosperms. CBS publishers and distributors, New Delhi.
10. Faegri, K. and Van der Pijl, L. 1969. The principal of polliation ecology. Peragamon Press, Toronto.
11. Bhatnagar, S.P. and Moitra, A. 1996. *Gymnosperms*. New Age International Pvt. Ltd. New Delhi.
12. Chamberlain, C.J. 1934. Gymnosperms, Structure and evolution. University of Chicago press.
13. Chaya Biswas and Johri, B.M. 1997. The gymnosperms. Narosa Publishing house. New Delhi
14. Sporne, K. R. (1991). The Morphology of Gymnosperms. Hutchinson & co.
15. Esau, K. 1972. Plant anatomy. John Wiley.
16. Arnold, C.A. 1947. An introduction to Palaeobotany. Mc Graw Hill.
17. Andrews, H.N. 1961. Studies in Palaeobotany. John Wiley
18. Steward, W.N. and Rothwell, G.W. 1993. Palaebotany and the Evolution of Plants 2nd edit. Cambridge Univ. Press. New York.
19. Fahn, A. 1997. Plant anatomy. IV edit. Aditya book Ltd. New Delhi.
20. Buvat, R. 1998. Ontogeny, cell differentiation and structure of vascular plants, Springer-Verlag.
21. Cutter, E.G. 1971. Plant Anatomy: Experiment and Interpretation. Vol. 1 & 2. Edward Arnold.
22. Sporne, K.R. 1965. The morphology of Angiosperms. Hutchinson & Co.
23. Larsens P.R. 1994. The vascular cambium. Springer-verlag.
24. Matthack, C. 1995. Wood- The internal optimization of trees. Springer-verlag.
25. Iqbal. M. 1990. The vascular cambium. John Wiley.
26. Raghavan, V. 1999. Development Biology of flowering plants. Springer-verlag, New York.

BOT(P) - 202(C): Gymnosperm, Anatomy, Reproductive Biology and Embryology (3 Credits)

1. Comparative study of the anatomy of vegetative and reproductive parts of locally available gymnosperms *viz*., *Cycas, Pinus, Cryptomeria, Cupressus, Cephalotaxus, Gnetum*.
2. Study of fossil gymnosperms from prepared slides.
3. Study of different types of fossils with help of specimens.
4. Study of anomalous secondary growth by preparing the permanent double stained slides.
5. Study of different types of stomata with the help of leaf peel preparations.
6. Study of types of ovules and stages of embryo (Globular type and heart shaped)
7. Preparations of temporary mounts of pollinaria of Orchids and Asclepiads.
8. Study from permanent slides, wall layers of anther, pollen, ovule, megasporogenesis, embryosac development, endosperm and embryo.
9. Study of anther wall layers in the transverse sections of members of family Solanaceae, Cruciferae and Liliaceae.
10. Dissection and preparation of whole mount of endosperm and endosperm haustoria from *Schichium edulis* seeds.

Suggested Readings: As in **BOT(T) - 201(C).**

BOT(T) - 203(C): Plant Biochemistry and Physiology (4 Credits)

Objectives: This paper deals with the different aspects of plant biochemistry and plant physiology. Students will gain knowledge about some important aspects of biochemistry, biosynthetic and metabolic pathways, plant metabolism, factors affecting plant growths etc. The knowledge so gathered in this paper can be utilized in the subsequent semesters/papers. Efforts are being made to accommodate most of the important aspects of plant biochemistry and physiology which can be completed in one semester duration.

Unit-I

Principles of thermodynamics; Free energy and chemical potential, redox reactions, significance of thermodynamics in living system; Structure and functions of carbohydrates, lipids and proteins; primary, secondary, tertiary and quaternary structures of protein. Amino Acid pKa, Protein PI. Biosynthesis of sucrose, starch, cellulose, fatty acid and β-oxidation.

Unit - II

Structure and function of enzyme active site, regulation of enzyme activities, enzyme kinetics including Michaelis-Menten equation. Overview of signal transduction, receptors, primary and secondary messengers, G-proteins, phospholipid signaling, cyclic nucleotides and calcium-calmodulin cascades.

Unit - III

Plant water relations, mechanism of water transport through xylem, xylem and phloem transport, phloem loading and unloading, passive and active transport; Photosynthesis (photo oxidation of water, cyclic and non-cyclic photophosphorylation, Calvin cycle, C_3, C_4 and CAM pathways); Photorespiration; Different phases of respiration (Glycolysis, Citric acid cycle, ETC/ETS); cyanide resistant respiration/alternative oxidase system. Pentose phosphate pathways (inter-conversion of hexoses and pentoses).

Unit IV

Biosynthesis and mechanism of action of Auxins, Cytokinins, Abscisic acid, Gibberellins, Ethylene, Biological role of brassinosteroids, polyamines, TDZ. Role of photoperiodism and phytochrome in flowering, vernalization. Role of photoperiodism and phytochrome in flowering, vernalization; Mechanism of seed germination; Dormancy, Senescence, Acclimation.

Suggested Readings

1. Nelson D. L. and Cox M. M., 2005. Lehningers' Principles of Biochemistry (4th Edition). W. H. Freeman and Company, 41 Madison Avenue, New York, NY 10010.
2. Peter J. Lea and Leegood R. C., (eds.). 2002. Plant Biochemistry and Molecular Biology (3rd edition). John Wiley and Sons Ltd., England.
3. Taiz L. and Zeiger E., 2003. Plant Physiology (3rd edition). Panima Publishing House, New Delhi.
4. Salisbury F. B and Ross C W., 2005. Plant Physiology (4th edition). Thomson Asia Pte Ltd., Singapore.
5. Hopkins W. G. and Huner N. P., 2004. Introduction to Plant Physiology (3rd edition). John Wiley & Sons, Inc.
6. Moore T. C., 2000. Biochemistry and Physiology of Plant Hormones (3rd edition). Springer-Verlag, New York.
7. Thomas B. and Vince-Prue, D. 2004. Photoperiodism in Plants (3rd edition). Academic Press San Diego, USA.
8. Nobel P. S., 2005. Physiochemical and Environmental Plant Physiology (3rd edition). Academic Press, San Diego, USA.

BOT(P) - 204(C): Plant Biochemistry and Physiology (3 Credits)

Practical Exercises

1. Estimation of sugar.
2. Estimation of amino acids.
3. Estimation of protein.
4. Effect of substrate concentration on enzyme activity and determination of its Km value.
5. Effect of temperature and *p*H on enzyme activity.
6. Extraction of different photosynthetic pigments and preparation of their absorption spectra.
7. Quantification of Chlorophyll *a, b* in C_3 and C_4 plants and their ratio.
8. Study the effects of light quality and intensity on hill reaction.
9. Assay of amylase induction by GA in plant tissue.
10. Assay of effect of cytokinin on chlorophyll degradation by leaf disc method.

Suggested Readings (Also refer books suggested for theory paper)

1. Bajracharya, D. 1999. Experiments in Plant Physiology: A Laboratory Manual. Narosa Publishing House, New Delhi.
2. Sadasivam S. and Manickam A., 2005. Biochemical Methods (4th edition). New Age International (P) Lts., Publishers, India.
3. Dennison, C. 1999. A Guide to Protein Isolation. Kluwer Academic Publishers, Dordrecht, The Netherland.
4. Plummer, D. T. 2000. An Introduction to Practical Biochemistry. Tata McGraw-Hill Publishing Co. Ltd., New Delhi.

Suggested Journals

1. Annual Review of Plant Biology
2. Current Opinion in Plant Biology
3. Journal of Experimental Botany
4. Plant Cell
5. Plant Cell Environment
6. Plant Journal
7. Plant Physiology
8. Tree Physiology
9. Trends in Plant Sciences

BOT(T) - 205(C): Environment, Biodiversity and Biostatistics (4 Credits)

Objectives: To equip students with an understanding of environmental pollution, its impact on plants, strategies bioremediation, and pollution monsitoring. Global environmental issues, including climate change and biodiversity conservation, with a focus on sustainable practices and policies. Skills in biostatistics for analyzing ecological and environmental data.

Unit-I

Environmental Pollution: Air, Water and Soil pollution: impact on plants. Heavy metal pollutant and contaminant and its effects on plants, Bioremediation/Phytoremediation, Biomagnifications & Bioaccumulation, Biomonitoring and Bioindicator; Carbon Sequestration, Pollution monitoring bodies.

Unit-II

Global Environmental Issues: Ozone layer depletion: causes, consequences and mitigation, Climate change: Drivers of climate change, greenhouse gas effects, Implication and mitigation, Effect of CO2 fertilization, Eutrophication, acid rain and atmospheric deposition of nutrients and trace elements. Impact of climate change on productivity.

Unit- III

Introduction to Biodiversity: Biodiversity: Definition, levels of biodiversity, uses and values of Biodiversity; Biopiracy; Conservation of Biodiversity: Convention on Biodiversity (CBD), Biological Diversity (Amendment) Act 2023, Role of WWF, WCU, CITES, TRAFFIC, In-situ and Ex-situ conservation approaches; Management of biodiversity: Sustainable Development Goals, Concept of Community Conserved Areas (CCA), People's Biodiversity Registers (PBRs), Protected Area Network (PAN), Other Effective Area-based Conservation (OECMS).

Unit-IV

Biostatistics: Application and uses of Biostatistics, S.D., S.E., hypothesis testing: Concept of P value; Test statistics like t-test (paired and unpaired) and Chi square ($\chi 2$) or Z2–test; basics of linear Regression, ANOVA or F-test (one, two- and three-ways ANOVA). sampling methods, comparison of means: t-test, multiple range tests, Simple experimental design and analysis of variance, correlation and regression analysis, Introduction to multivariate methods, Types of statistical software and their application in analysis of data.

Suggested Readings

1. Sharma, B.K. Environmental Chemistry (2nd Edition). Goel Publishing House, New Delhi.
2. Odum E.P (1971) Fundamentals of Ecology. W.B Saunders
3. Wittaker W.H (1975) Comminities and Ecoystems, Mc Millan
4. Barnes, R.S.K. (1998). Diversity of living organisms. Blackwell Sciences Ltd, U.K
5. Barthlott, W. and Winger W. (2001). Biodiversity. Springer-Verlag, New York
6. Chapman, J.L and Reiss, M.J. (1988). Ecology, principles and applications, Cambridge Univ Press U.K
7. Frankel, O.H., Anthony, H.D and Burdo, J.J (1995). Conservation of Plant Biodiversity. Cambridge Univ Press, Cambridge.
8. Dutta, N.K. (2002). Fundamentals of Biostatistics, Practical Approach, Kanishka Publishers distributors, New Delhi-110002
9. Gupta, S. P. (2011). Statistical Methods, 40th First edition, Sultan Chand and Sons, Darya Ganj, New Delhi-110002
10. Ramakrishanan, P. (1996). Biostatistics, Soras Publication, Kanyakumari. Nagercoil- 2.

BOT(T) - 206(C): Environment, Biodiversity and Biostatistics (Practical) (3 Credits)

1. Estimation of the various physico-chemical parameters of water samples viz., pH, water temperature, transparency, Conductivity, Turbidity, Free CO_2, TDS, DO, BOD, COD, Chloride, total Alkalinity, Ca and Mg hardness, total hardness, NO_3-N, PO_4-P and K.
2. Estimation of the various physico-chemical parameters from the forest soil samples viz., pH, soil temperature, soil moisture content, porosity, bulk density, soil texture, redox potential, cation exchange capacity, conductivity.
3. Development of People's Biodiversity Register (PBR).
4. To solve the various Biostatistics Problems based on theoretical topics.

Suggested Readings (Also refer books suggested for theory paper):

1. Misra, R. (1968). Ecology Workbook. Oxford & IBH.
2. Trivedy, R.K and Goel, P.K. (1986). Chemical and Biological Methods for Water Pollution Studies. Environmental publications.
3. Muller dombois and Ellenberg H. (1974). Aims and methods of Vegetation Ecology. John Wiley & Sons.
4. Smith R.L. (1996). Ecology and Field Biology. Harper Collins, New York.
5. Dutta, N.K. (2002). Fundamentals of Biostatistics, Practical Approach, Kanishka Publishers distributors, New Delhi-110002
6. Gupta, S. P. (2011). Statistical Methods, 40th first revised edition, Sultan Chand and Sons, Darya Ganj, New Delhi-110002
7. Ramakrishanan, P. (1996). Biostatistics, Soras Publication, Kanyakumari. Nagercoil- 2
8. APHA. (2020). American Public Health Association, Standard Methods for the Examination of Water and Wastewater, Method 1020.
9. Jackson, M.L. (1973). Soil Chemical Analysis. Prentice Hall of India Pvt. Ltd., New Delhi (India)

BOT(T) - 301(C): Molecular Biology and Cytogenetics (4 Credits)

Objectives: This paper deals with the different aspects of cell biology/cytology including plant cell structure, components and functions; different aspects of genetics and plant breeding. Paper also deals with structure and function of genes and their regulation, population genetics and basic aspects of gene interactions and its rule in plant breeding.

Unit - I

Structural organization of plant cell, cytoskeleton; Chloroplast and mitochondria genome organization and gene expression; Structure and function of tonoplast membrane, Golgi apparatus, endoplasmic reticulum. Structure and function of nucleus, nucleosome organization, packing of DNA into chromosomes. DNA replication, DNA damage and repair.

Unit-II

Pro and eukaryotic transcription, plant promoters and transcription factors; mRNA processing, Genetic code. Translation in pro and eukaryotic system, protein maturation; Targeting of proteins to different organelles; Control mechanisms of cell cycle, role of cyclins and cyclic-dependent kinases, retinoblastoma and E2F proteins on cell cycle; Mechanisms of programmed cell death.

Unit - III

Gene-modern concept, split gene, overlapping genes, gene clusters and repeats, Chromosome types, Karyotype and chromosome banding pattern; Principles of Mendelian inheritance and interaction of genes, duplications, deficiencies, inversions, interchanges, ploidy and their cytological consequences, Cytoplasmic inheritance and interaction between nuclear and cytoplasmic genes. Recombination and construction of recombination maps, transposons.

Unit - IV

Qualitative and quantitative traits, inheritance of quantitative traits, heritability and factors affecting heritability, linkage types, Hardy-Weinberg law, factors affecting H-W equilibrium, mechanism and types of speciation, principles of plant breeding, methods, special approach to crops, evaluation and multiplication.

Suggested Readings

1. Nelson D L & Cox M M (2008). Lehninger's Principles of Biochemistry (5th Edition). W. H. Freeman & Company, New York.
2. Lewin B (2011). Genes X. Oxford University Press, New York.
3. Gardner E J & Snustad D P (1991). Principles of Genetics. Jhon Wiley & Sons, USA.
4. Russell P J (1998). Genetics. The Benzamin Cummings Publishers, USA.
5. Snustad D P & Simmons M J (2006). Genetics (4th Edition). John Wiley & Sons, USA.
6. Strickberger M W (2005). Genetics (3rd Edition). Prentice Hall, New Delhi, India.
7. Uppal S, Yadava R, Subhadra & Saharan R P (2005). Practical Manual on Basic and Applied Genetics. CCS HAU, Hisar, India.
8. Bos, I & Caligari P (1995). Selection Methods in Plant Breeding. Chapman & Hall, London.
9. Falconer D S & Mackay (1998). Introduction to Quantitative Genetics. Longman, London.
10. Mather K & Jinks J L (1971). Biometrical Genetics. Chapman & Hall, London.
11. Mather K & Jinks J L (1983). Introduction to Biometrical Genetics. Chapman & Hall, London.
12. Nadarajan N & Gunasekaran M (2005). Quantitative Genetics and Biometrical Techniques in Plant Breeding. Kalyani Publishers, New Delhi.

BOT(T) - 302(C): Molecular Biology and Cytogenetics (Practical) (3 Credits)

1. Isolation and purification of plant DNA.
2. Quantification of DNA by spectrophotometric method.
3. Isolation and purification of plant RNA.
4. Quantification of RNA by spectrophotometric method.
5. Agarose Gel Electrophoresis of Nucleic Acid.
6. Probability and chi-square test for genetic analyses.
7. Preparation of karyotype and ideogram.
8. Preparation of metaphase slide from suitable plant material.
9. Study of different mitotic stages from suitable plant material.
10. Study of meiosis.
11. Calculation of genetic allele frequency of Campus Students.

Suggested Readings: As BOT(T)-301(C).

BOT(T)-303(C) Plant Diversity, Ecology and Ecosystem Studies (4 Credits)

Objectives: To understand the fundamentals of plant ecology and learn about the complex processes in population and community ecology. Recognize the importance of ecological interactions in shaping the structure of ecological communities. To make students learn about the structure and functional ecology of various ecosystems.

Unit - I

Biological Diversity: Scope of biodiversity, role of biodiversity in ecosystem stability; Speciation and extinction; IUCN categories of threat; Biodiversity Hot spots and mega diversity regions of the world; biodiversity measurement; Threats to biodiversity; Centre of plant diversity, Status of plant diversity conservation in India.

Unit - II

Population and Community Ecology: Species distribution: Population characteristics, population growth forms, and structure, energy partitioning, r and k-selection, Survivorship curve, life table analysis and age-structured populations; Population dynamics and plant population regulation, Population interactions and allopathy. Mechanisms of plant community development. Models of Succession. Concept of Niche; Niche and Geographic Distribution. Steps to Building Niche Models; Species Occurrence data- types; Types of modelling algorithms; Introduction to Maximum Entropy Model; Applications.

Unit - III

Ecosystem Structure and Function: Primary production and its measurements and regulating factors, nutrient cycling, energy flow model, Classification of freshwater ecosystems; water quality parameters (physico-chemical and biological), Structure, energy flow and productivity in freshwater ecosystems; Limiting factors, influence of light, temperature and chemicals in freshwater ecosystem.

Unit - IV

Ecosystem Services and Restoration: concept of ecosystem services, relationship between ecosystem services to biodiversity and natural capital, Monetary valuation of ecosystem services; non-monetary valuation–methods and approaches. Ecological Restoration: Ecological Restoration: concept and scope of restoration, restoration process, restoration of wetlands, rivers, wildlife, grasslands, temperate and tropical forests.

Suggested Readings

1. Odum, E.P. (1971). Fundamentals of Ecology. W.B Saunders.
2. Kormondy, E.J. (1978). Concept of Ecology. Prentice Hall.
3. Odum, E.P. (1983). Basic Ecology. Saunders, Philadelphia.
4. Smith, R.L. (1996). Ecology and field Biology. Harper Collins New York.
5. Muller dombios, D and Ellenberg, H. (1974). Aims and methods of Vegetation Ecology, Wiley, New York.
6. Begon, M. Harper, J.L and Townsend, C.R. (1996). Ecology Blackwell Science, Cambridge, USA.
7. Brandy, N. C. (1990). The nature and property of soils, Macmillan.
8. Hill, M.K (1997). Understanding Environmental Pollution, Cambridge University Press.
9. Treshow, M. (1985). Air Pollution and Plant life. Wiley Interscience.

10. Whittaker, R.H. (1975). Communities and Ecosystems. Macmillan.
11. Wild, A. (1994). Soil and Environment. Cambridge Univ. Press.
12. Mason, C.F. (1991). Biology of Freshwater Pollution, Longman.
13. Petersonm A. T., Soberón J., Pearson, R. G., Anderson, R. P., Martínez-Meyer, E., Nakamura, M., Araújo, M. B. (2011). Ecological Niches and Geographic Distributions, Princeton University Press.
14. Gillman, M. and Hails, R. (1997). Introduction to Ecological Modelling. Blackwell Science Ltd.
15. Pomeroy, L.R. and Alberts, J. J. (2011). Concepts of Ecosystem Ecology: A Comparative View. Springer-Verlag New York Inc.

BOT(P)-304(C) Plant Diversity, Ecology and Ecosystem Studies (Practical) (3 Credits)

1. To find out the relative density, relative frequency, relative dominance and IVI in plants community to determine diversity indices.
2. To determine the density and basal areas, tree height, canopy cover of trees in a forest stand.
3. Study of similarity between plant communities using index of similarity and dissimilarity.
4. Ecological Niche model.
5. Harvesting method, light and dark bottle method for estimation of productivity.

Suggested Readings

1. Muller dombois and Ellenberg, H. (1974). Aims and methods of Vegetation Ecology. John Wiley & Sons.
2. Smith R.L. (1996). Ecology and Field Biology. Harper Collins, New York.
3. Anne, E. Magurran. (1988). Ecological Diversity and its Measurement. Chapman and Hall, New York.
4. Anne, E. Magurran. (1988). Ecological Diversity and its Measurement. Chapman and Hall, New York.

BOT(T) - 305(C): Plant and Environmental Biotechnology (4 Credits)

Objectives: It is very important to understand the basics of different fundamental functions of any organism at molecular level. Further, the use different emerging technologies/tools in biological science are necessary for human welfare. This paper deals with different biological processes at molecular level and different modern techniques in the field of biotechnology with reference to plants and environmental biotechnology for sustainable future. This paper will help in getting employment in 'Plant Tissue Culture Industry/Lab, Biotechnology Industry/Lab, Faculties/ Scientists in the Colleges/University/Research Institutes. Further, the students can start their own entrepreneurship unit/Startup.

Unit - I

Plant Tissue Culture: Biotechnology: Concepts, definitions, principles and scope; Micropropagation techniques; different types of natural and synthetic plant growth regulators in tissue culture; Somatic embryogenesis; Production of virus-free plants; Somaclonal variation and it application.

Unit - II

Industrial Biotechnology and Germplasm Conservation: Haploid production in culture and application in agriculture; Protoplast isolation and culture, somatic hybridization, cybridization, application and limitation of protoplast research; Production of commercially useful secondary metabolites in culture; Conservation of germplasms in vitro- 'slow growth technique, and cryopreservation; Fermentation Technology: Concepts, definitions and techniques of fermentation technology.

Unit - III

Molecular Biotechnology: Gene cloning principles and techniques, restriction endonucleases, cloning vehicles; Construction of genomic library and cDNA library; Transgenic plants and its application; Nucleic acid hybridization (southern, northern and western blotting), Different types of PCR, Basic DNA sequencing technique; Genetic and physical mapping of genes; artificial chromosome.

Unit - IV

Environmental Biotechnology and Ethics: Plant-microbes interaction and plant growth promoting microbes; Biotechnology and environment: biofilm, bioplastic, microbial fuel cell, judicious use of biological pesticides, bioindicators, Intellectual property right and bioethics.

Suggested Readings

1. Bhojwani S. S. and Razdan M. K., 2006. Lant Tissue Culture: Theory and Practice (Revised Edition). Elsevier Science B. V.
2. Bhojwani S. S. and Dantu P K. 2013. Plant Tissue Culture: An Introductory Text. Agritech Publications, P.O. Box 255, Shrub Oak, NY 10588, U.S.A.
3. Kurz W. G. W., 1989. Primary and Secondary Metabolism of Plant Cell Cultures II. Springer-Verlag.
4. Jain S. M., Gupta P. K. and Newton R. J. (eds.).2000. Somatic Embryogenesis in Woody Plants. Vol.

6. Kluwer Academic Publishers.
5. Primrose S. B. 2000. Principles of Genome Analysis. Blackwell Scientific Publications, Oxford, UK.
6. Kartha K. K., 2000. Cryopreservation of Plant cells and Organs. CRC Press, Boca Raton, Florida, USA.
7. Nirmala C. B., 2009. Plant Biotechnology. MPJ Publishers, Chennai, India.
8. Meenambal T., 2009. Environmental Science and Engineering. MPJ Publishers, Chennai, India.
9. Lohar P. S., 2009. Bioinformatics. MPJ Publishers, Chennai, India.
10. Hepsyba S. G. H., 2008. Basic Bioinformatics. MPJ Publishers, Chennai, India.
11. Kalaichelvan P. T. and Pandi A., 2009. Bioprocess Technology. MPJ Publishers, Chennai, India.
12. Kalaichelvan P. T., 2008. Microbiology and Biotechnology: A Laboratory Manual. MPJ Publishers, Chennai, India
13. Glicks B. R. and Pasternack J. J., 2004. Molecular Biotechnology. ASM Press.
14. Shanthanan S. and Montgomery J. F., 1999. Biotechnology, Biosafety and Biodiversity. Oxford and IBH Publishing Co. Pvt. Pvt., New Delhi.
15. Smith R. H., 2000. Plant Tissue Culture: Techniques and Experiments (2nd edition). Academic Press.
16. Sibi G. 2022. Environmental Biotechnology: Fundamentals to Modern Techniques (Emerging Materials and Technologies). CRC Press.
17. Pradeep Verma. 2025. Biotechnology for Environmental Sustainability. Springer Nature.
18. Bruce E. Rittmann and Perry L. McCarty. 2020. Environmental Biotechnology: Principles and Applications, 2nd Edition. McGraw-Hill Education.

BOT(T) - 306(C): Plant and Environmental Biotechnology (Practical) (4 Credits)

1. Preparation of plant tissue culture media and techniques for initiation of aseptic culture.
2. Initiation of carrot callus culture and induction of somatic embryogenesis.
3. Micropropagation of economically important local plants.
4. Initiation of haploid culture.
5. Initiation embryo/organ culture.
6. Immature embryo culture of economically important orchids for mass multiplication.
7. Isolation of DNA and agarose gel electrophoresis.
8. Demonstration of isolation of mRNA and plasmid.
9. Colony PCR.
10. Gradient PCR
11. Isolation of growth promoting microbes.

Suggested Readings As in Theory Paper +

1. Sambrook J., Russell D.W. 2001. Molecular Cloning-A Laboratory Manual, Vols I-III, Cold Spring Harbor Laboratory, USA.
2. Buchanan B., Gruissem G., Jones R. 2015. Biochemistry and Molecular Biology of Plants, 2nd Edition, American Society of Plant Physiologists, USA.

BOT(T) - 401(C): Project + Internship (8 + 4 Credits)

Objectives: The Post Graduate students are the future Scientists of the Nation. It is very important to develop a bridge between the formal classrooms teaching-learning and formal research. The purpose of this course is to introduce the PG students in the field of research enabling them to ignite their mind and develop analytic approach. Student will take a small research topic which is doable within a period of two semesters and the outcome of the study will be presented in the form of 'Dissertation'. Further, students will be allowed for 'Industrial Visit, National Research Laboratories of their choice for a short duration or 'Academic Study Tour' as per the University rule.

Students will be allotted project work in the beginning of 3rd Semester and '**Dissertation**' will be evaluated at the end of 4th Semester for 8 Credits. Students can opt for any one from the broad areas given below. On completion of the dissertation work, students will submit the printed and bound dissertation and present the work as PowerPoint presentation. Besides this student need to undertake '**Internship**' of at least 15 working days from any **Institute/Industry or Industrial Visit** of students' choice. The '**Internship Visit'** will carry 04 credit. On completion of the **internship**, students will submit the report and certificate for evaluation.

Broad areas of specialization through Project Work

Higher Plant Ecology, Biodiversity Conservation & Ecosystem analysis (Aquatic and terrestrial ecosystems), Phytogeography, Microbial Ecology, Food Fermentation, Plant Molecular Biology, Plant Physiology, Biochemistry, Food Chemistry/Food Technology, Reproductive Biology, Seed Biology, Plant Tissue Culture, Plant Biotechnology, Plant Genetics & Cytogenetics, Angiosperm Taxonomy, Ethnobotany, Lower plants etc.

Note: If due to any unavoidable circumstances, Internship cannot be conducted by the University/Department, 'Dissertation' will be evaluated for 12 credits.

BOT(T) - 402(CBCP): Angiosperm Taxonomy and Biosystematics (4 Credits)

Objectives: This paper introduces advanced concepts and scope of Taxonomy. It also introduces show to refer classical and recent literatures related to taxonomy. The students will also learn about phylogenetic tree and phenetic approach to classification along with scope and concept of biosystematics.

Unit - I

Plant Systematics: Management of herbarium and documentation, ancillary collections and handling of special groups, author citation and nomenclature; Type method and population concept; Preparation and publication of floristic accounts, general hints for writing floras, revisions, monographs; Publication of a new taxon.

Unit - II

Plant Identification Processes: Classical and recent literatures; Taxonomic Literature; General indexes, floras and manuals, dictionaries and glossaries, pictorial encyclopaedias, periodicals; Types of taxonomic keys, construction of keys; polyclave/random access/synoptic keys, advantages of polyclave keys; BSI, its establishment and activities.

Unit - III

Forest Resources and Traditional Knowledge: General forest types of North East India; Ethnobotanical concepts and scope; Methods and techniques of ethnobotanical research. Role of botanical gardens, major botanical gardens in India, Royal Botanical Garden, Kew.

Unit - IV

Current Trends in Taxonomy: Phyletic taxonomy, cladistic taxonomy, taximetrics, serological approaches in taxonomy; Techniques in biosystematic studies, biosystematic categories and its significance, limitations of biosystematics.

Suggested Readings

1. Davis, P.H. and Heywood, V.H. 1973. Principles of Angiosperms Taxonomy. Robert E. Kreiger Pub. Co., New York.
2. Grant, V. 1971. Plant Speciation. Columbia University Press, New York.
3. Grant, W.F. 1984. Plant Biosystematics. Academic Press, London.
4. Harrison, H.J. 1971. New Concepts in Flowering Plant Taxonomy. Nieman Educational Books Ltd., London.
5. Heslop-Harrison, J. 1967. Plant Taxonomy. English Language Book Soc. & Edward Arnold Pub. Ltd., UK.
6. Heywood, V.H. and Moore, D.M. 1984. Current Concepts in Plant Taxonomy. Academic Press, London.
7. Jain, S.K. 1981. Glimpses of Indian Ethnobotany. Oxford and IPH.
8. Jain, S. K. and Rao, R.R. 1977. A Handbook of Field and Herbarium Methods. Today and Tomorrow.
9. Jones, A.D. and Wilbins, A.D. 1971. Variations and Adaptations in Plant Species. Hieman & Co. Educational Books Ltd., London.

10. Jones, S.B., Jr. and Luchsinger, A.E. 1986. Plant Systematics (2nd edition). McGraw-Hill Book Co., New York.
11. Mondal, A. K. 2011. Advanced Plant Taxonomy. New Central Book Agency, Kolkotta.
12. Naik, V. N. 1990. Introductory Plant Taxonomy. Longman.
13. Nordenstam, B., El Gazaly, G. and Kassas, M. 2000. Plant Systematics for 21st Century. Portlant Press Ltd., London.
14. Radford, A.E. 1986. Fundamentals of Plant Systematics. Harper & Row Publications, USA.
15. Solbrig, O.T. 1970. Principles and Methods of Plant Biosystematics. The MacMillan Co.-Collier-MacMillan Ltd., London.
16. Solbrig, O.T. and Solbrig, D.J. 1979. Population Biology and Evolution. Addison-Wesley Publication Co. Inc., USA.
17. Stebbins, G.L. 1974. Flowering Plant – Evolution above Species Level. Edward Arnold Ltd., London.
18. Stace, C.A. 1989. Plant Taxonomy and Biosystematics (2nd edition). Edward Arnold Ltd., London.
19. Takhtajan, A.L. 1997. Diversity and Classification of Flowering Plants. Columbia University Press, New York.
20. Verma, B. K. 2011. Introduction to Taxonomy of Angiosperms. PHI Learning Pvt. Ltd., New Delhi.
21. Woodland, D.W. (1991). Contemporary Plant Systematics. Prentice Hall, New Jersey.
22. Dallwitz, M.J., Paine, T.A., and Zurcher, E.J. 91995). Delta: a general system for processing taxonomic descriptions:
23. User,s Guide. CSIRO Publishing. ISBN-10:0643301961.
24. Ashok, B and Ashok, K. (2004). A textbook of practical Botany. Vol (I&II). Rastogi Publication, Meerut.

BOT(P) - 403(CBCP): Angiosperm Taxonomy and Biosystematics (3 Credits)

1. Comparative studies of monocot and dicot families of flowering plants.
2. Preparation of herbarium with locally available plants and submission.
3. Description and identification of plants up to species level.
4. Construction of taxonomic keys.
5. Practical handling of floras and manuals for identification.

Suggested Readings are same as in BOT(T) - 404(CBCP).

BOT(T) - 404(CBCP): Biodiversity Conservation and Ecosystem Analysis

(4 Credits)

Objectives: To gain an understanding of (i) basic concepts and scientific principles of conservation and global patterns in biodiversity (ii) Current efforts to conserve biodiversity at global, national and local scales (iv)To understand the different analytical procedures for the estimation of ecological parameters for both the terrestrial and aquatic ecosystem viz., various physico-chemical parameters of soil and water, litter chemistry, microbial biomass C, N and P, net N mineralization potential, Carbon stock in both the soil and plant biomass, soil respiration etc.

Unit–I: Overview of Global Biodiversity: Methods of inventorying biodiversity; Measurement and indices of biodiversity; Major drivers of biodiversity change. Threats to Biological diversity. Concept of sustainable development; Indigenous Traditional Knowledge (ITK); Peoples Biodiversity Register; Biodiversity and Intellectual Property Rights (IPR), TRIPS.

Unit - II Conservation strategies: Principles of biodiversity conservation, Global protected area network, National Biodiversity Authority. India - Biosphere reserves, Biodiversity management approaches; Indian case studies with special reference to North east India *viz*., protected area network and biosphere reserves, Convention on Biodiversity, CITES.

Unit-III: Terrestrial Ecosystem Dynamics: Forest biomass and Carbon stock, measurement of biomass and productivity, litter production and decomposition, biomass and turnover, mineralization and immobilization of organic matter, nutrient cycling, significance of C:N ration, factors affecting litter fall production and decomposition, nutrient dynamic in forest ecosystems, Concept of soil carbon sequestration, soil quality and carbon sequestration, soil organic carbon pool, plant biomass and carbon, Carbon dioxide sequestration in different compartments of plant biomass .

Unit-IV: Freshwater Ecosystem Process: Lentic and lotic water bodies and their ecology**,** Biomass and productivity study in aquatic ecosystem. Factors affecting productivity in aquatic ecosystem, Nutrient spiraling concept, River-continuum concepts, limiting factors, Effects of light, temperature, Dissolve Oxygen, turbidity and chemicals factors in controlling aquatic ecosystem.

Suggested Readings

1. Kurt Jax. (2010). Ecosystem Functioning. Cambridge University Press.
2. Walter K. Dodds. (2002). Freshwater Ecology: Concepts and Environmental Applications. Academic Press.
3. Wetzel, R.G. (2001). Limnology. (3rd Ed.). Academic Press.
4. Goran I. Agren, Folke-O Andersson. (2011). Terrestrial Ecosystem Ecology. Cambridge University Press.
5. Julian Reynolds, Catherine Souty-Grosset. (2011). Management of Freshwater Biology. Cambridge University Press.
6. Hynes, H. B .N. (1970). The Ecology of Running Waters. Liverpool University Press.
7. Cummins, K. W. (1995). Lotic Limnology. Chapman and Hall, New York.
8. Whitton, B. A. (1975). River Ecology. Blackwell Scientific Publications, Oxford.
2. Lampert, W and Sommer, U. (2007). Limno Ecology. (2nd edition). Oxford University Press.

3. Barnes, B.V., Zak, D R., Denton, S.R and Spurr, S.R. (1998). Forest Ecology. (4th edition). John Wiley and Sons.
4. Newton, A. (2007). Forest Ecology and Conservation. Oxford University Press.
5. Raymond, Y.A. and Ronald G.L. (2003). Introduction to forest ecosystem: science and management (3rd Edn.). John Wiley and sons.
6. Gaston, K.J. and Spicer, J.I. (2004). Biodiversity: An introduction (2nd edition).Wiley and Black.
7. Frankel, O.H., Anthony, H.D and Burdo, J.J. (1995). Conservation of Plant Biodiversity. Cambridge Univ Press, Cambridge.
8. Jelte Van Andel and Aronson. (2006). Restoration Ecology. Blackwell Science Ltd.
9. Peggy L Fielder and Peter M Kareiva. (1998). Conservation Biology, Chapman & Hall, International Thompson Inc.
10. Oliver S. Owen and Daniel D. Chiras. (1995). Natural Resource Conservation-Management for a Sustainable Future. Prentice Hall, Englewood Cliffs, New Jersey.
11. Francisco A. Comin. (2010). Ecological Restoration. Cambridge University Press.
12. Lennart Hansson. (1992). Conservation Ecology Series: Principles, Practices and Management. Springer.
13. Singh, J.S., Singh, S.P. and Gupta S.R. (2006). Ecology, Environment and Resource Conservation. Anamaya Publishers, New Delhi.

BOT(P) - 405(CBCP): Biodiversity Conservation and Ecosystem Analysis (3 Credits)

1. To determine different diversity indices of plant communities.
2. To determine the soil respiration.
3. Study of forest soil profile.
4. Estimation of biomass allocation both above and belowground and productivity of forest ecosystem.
5. Quantification of litter production and decomposition.
6. Estimation of Carbon in soil and tree biomass for the calculation of Carbon stock.
7. Estimation of soil and litter organic Carbon concentration using dichromate-oxidation-sulphate-ferrous titration method.
8. Estimation of Total and available Nitrogen concentration in soil and litter using Nitrogen Analyzer.

Suggested Readings

1. Anderson, J.M., and Ingram, J.S.I. (1993). Tropical Soil Biology and Fertility: A Handbook of Methods. C.A.B. International, UK.
2. Trivedy, R.K. (1986) Chemical and biological methods for water pollution studies. Environmental Publication, Karad
3. Walkley, A and Black, I.A. (1934) An examination of the detjareff method for determining soil organic matter and a proposed modification to the chronic acid titration method. Soil Sci 37:29–38
4. Ghosh, B.N., Bhattacharyya, R., Mishra, P.K., Singh, S.K., and Sankar, M. (2018). A practical manual on estimation of Carbon sequestration. ICAR-Indian Institute of soil and water conservation, Dehradun, India.44p.
5. Walkley, A.; Black, C.A. (1934). An experiment of Degtjareff methods for determining soil organic matter and proposed modification of the chronic acid titration methods. Soil Sci. 37: 29–38.
6. Jackson, M.L. (1958). Soil Chemical Analysis; Prentice Hall, Inc.: Englewood Clift, NJ, USA,
7. Muller dombois and Ellenberg, H. (1974). Aims and methods of Vegetation Ecology. John Wiley & Sons.
8. Smith R.L. (1996). Ecology and Field Biology. Harper Collins, New York.
9. Anne, E. Magurran. (1988). Ecological Diversity and its Measurement. Chapman and Hall, New York..

BOT(T) - 406(CBCP): Microbial Studies (4 Credits)

Objectives: Ecology of microorganisms, detail account of inter-specific relationships, biogeochemical cycling and bioremediation aspects will be discussed in detail.

Unit - I

Microbial Diversity: Microbial community, species diversity, microbial dispersal, types of dispersal; habit and niche, colonization, succession and climax

Unit - II

Microbial Ecology: Microbiology of soil, air, nutrients regeneration in ecosystem,
Agricultural Microbiology: Biofertilizers, nitrogen fixation,

Unit III

Plant-microbe Interaction: Inters-specific relationship of Symbiosis, competition. Parasitism, mycorrhizae and its application, endophytes and its importance and C, N, P cycles

Unit - IV

Environmental Microbiology: Microbes in relation to pollutants, biodegradation, biopesticides, sewage treatment, tolerance to extremes of environment.

Suggested Readings

1. Dubey, R.C and Maheshwari, D.K. A text book of Microbiology.(2009). S. Chand
2. Alexander M (1979). Advances in Microbial Ecology. Plenum Press.
3. Harley JL & Smith S E (1983). Microbial Symbiosis. Academic Press.
4. Atlas R M & Bartha R (1997). Microbial Ecology: Fundamental Applications (4th edition). Benjamin/Cummings Science Publication.

BOT(P) - 407(CBCP): Microbial Studies (3 Credits)

1. Culture techniques of certain dominant groups of microorganisms
2. Growth measurement of microorganisms.
3. Morphology of dominant microbes isolated from soil, air and litter.
4. Effect of certain physical and chemical factors on growth of microbes.
5. Study of mycorrhizal seedlings.
6. Study of mycorrhizal association and its impact on seedlings survival.

Suggested Readings: As in BOT(T) - 408.

BOT(T) - 408(CBCP): Plant Biotechnology (4 Credits)

Objectives: It is very important to understand the basics of different fundamental functions of any organism at molecular level. Further, the use different emerging technologies/tools in biological science are necessary for human welfare. This paper deals with different biological processes at molecular level and different modern techniques in the field of biotechnology with reference to plants. This paper will help in getting employment in 'Plant Tissue Culture Industry/Lab, Biotechnology Industry/Lab, Faculties/ Scientists in the Colleges/ University/Research Institutes. Further, the students can start their own entrepreneurship unit/Startup.

Unit - I

Plant Tissue Culture: Micropropagation techniques; Organ culture; Somatic embryogenesis and application; Haploid production and application; Protoplast isolation, purification, somatic hybridization, cybridization; Production of useful secondary metabolites in culture (use of bioreactors and immobilized cell culture)

Unit - II

Conservation Biotechnology Microbial Biotechnology: Role of biotechnology in conservation of PGRs (in vitro mass multiplication of plants, long-term preservation of germplasm through cryopreservation; Industrial microbiology (fermentation technology); Microbes as biofertilizer, PGPR and PGPF.

Unit - III

Molecular Biotechnology: Construction of rDNA and its application, cloning vehicles, construction of genomic and cDNA libraries, molecular markers for introgression of useful traits, transgenic plants and its application (nuclear and chloroplast); nucleic acid hybridization, PCR, Molecular profiling, DNA finger printing; Gene mapping techniques, Basic DNA sequence technique; Introduction to Triple helix DNA.

Unit - IV

Environmental Biotechnology and Bioethics: Biotechnology and Environment: Judicious uses of biofertilizers and biopesticides, bioindicator, biomagnifications of nondegradable pollutants, nonconventional and renewable energy sources in environmental pollution management; Metagenomics; Ethical issues; Biotechnology and biosafety, IPR.

Suggested Readings

1. Benson E. E., 1999. Plant Conservation Biotechnology (ed.). Taylor & Francis Ltd, USA.
2. Bhojwani S. S. and Razdan M. K., 2006. Lant Tissue Culture: Theory and Practice (Revised Edition). Elsevier Science B. V.
3. Bhojwani S. S. and Dantu P K. 2013. Plant Tissue Culture: An Introductory Text. Agritech Publications, P.O. Box 255, Shrub Oak, NY 10588, U.S.A.
4. Kurz W. G. W., 1989. Primary and Secondary Metabolism of Plant Cell Cultures II. Springer-Verlag.
5. Vasil I. K. and Thorpe T. A., 2005 (Indian Print). Plant Cell Tissue Culture. Kluwer Academic Publishers.
6. Jain S. M., Gupta P. K. and Newton R. J. (eds.).2000. Somatic Embryogenesis in Woody Plants. Vol. 6. Kluwer Academic Publishers.
7. Brown T. A., 1999. Genomes. John Wiley and Sons (Asia) Pvt. Ltd., Singapore.

8. Primrose S. B. 2000. Principles of Genome Analysis. Blackwell Scientific Publications, Oxford, UK.
9. Kartha K. K., 2000. Cryopreservation of Plant cells and Organs. CRC Press, Boca Raton, Florida, USA.
10. Mitra S., 2000. Genetic Engineering. Mc Milam Publication.
11. Singh B. D., 2005. Biotechnology. Kalyani publishers, New Delhi, India.
12. Jolles, O. and Jornvall H. (eds), 2000. Proteomics in Functional Genomics. Bikhauser Verlag, Basel, Switzerland.
13. Nirmala C. B., 2009. Plant Biotechnology. MPJ Publishers, Chennai, India.
14. Kalaichelvan P. T., 2008. Microbiology and Biotechnology: A Laboratory Manual. MPJ Publishers, Chennai, India
15. Glicks B. R. and Pasternack J. J., 2004. Molecular Biotechnology. ASM Press.
16. Smith R. H., 2000. Plant Tissue Culture: Techniques and Experiments (2nd edition). Academic Press.
17. Sibi G. 2022. Environmental Biotechnology: Fundamentals to Modern Techniques (Emerging Materials and Technologies). CRC Press.
18. Pradeep Verma. 2025. Biotechnology for Environmental Sustainability. Springer Nature.
19. Bruce E. Rittmann and Perry L. McCarty. 2020. Environmental Biotechnology: Principles and Applications, 2nd Edition. McGraw-Hill Education.

BOT(P) - 409(CBCP): Plant Biotechnology (3 Credits)

1. Micropropagation of economically important local plants through organ culture.
2. Induction of somatic embryogenesis.
3. Isolation of DNA and agarose gel electrophoresis & PCR
4. Isolation of mRNA and plasmid DNA
5. Colony PCR.
6. Gradient PCR
7. Isolation of growth promoting microbes..

Suggested Readings as in BOT(T) - 410 (CBCP) and

1. Sambrook J., Russell D.W. 2001. Molecular Cloning- A Laboratory Manual, Vols I- III, Cold Spring Harbor Laboratory, USA.
2. Buchanan B., Gruissem G., Jones R. 2015. Biochemistry and Molecular Biology ofPlants, 2nd Edition, American Society of Plant Physiologists, USA.

Suggested Journals

1. Nucleic Acid Research
2. Plant Biotechnology Journal
3. Plant Cell
4. Plant Cell Reports
5. Plant Journal
6. Plant Organ Tissue Culture.

BOT(T) - 410(CBCP): Plant Stress Physiology (4 Credits)

Objectives: This paper examines the essential elements of plant adaptation strategies. Stress resulting from fluctuating environmental conditions disrupts or modifies numerous physiological and metabolic processes in organisms; however, plants have developed various defense mechanisms to withstand external disturbances, including extreme conditions such as low temperature, heat, drought, and salinity, which are particularly pertinent in the context of global warming. The adaptation strategies encompass an integrated complicated mechanism, including from morphological to molecular changes. The paper will offer a solid foundation for individuals interested in plant adaptation.

Unit - I

Biotic and abiotic stresses, Plant responses to stresses (physiological), plant stress and reactive oxygen species, photo-oxidative damage, stress mitigation mechanism in plants (antioxidant and enzymatic), Asada-Halliwell pathway.

Unit - II

Role of plant hormones in stress response, phenotypic plasticity, shade avoidance, Mechanism of plant acclimation to stress, Seasonal and stress induced senescence, seed, and bud dormancy in trees (biochemical, cellular, and molecular mechanism).

Unit III

Tree drought physiology: mechanisms for water uptake, storage, and conservation, root system, water transport and transpiration, stomatal regulation, osmoregulation, photosynthesis, leaf shedding, root growth, drought tolerance and recovery. Tree seed types, mechanism of seed germination and seedling survivability. Brief introduction to symbiotic association in trees.

Unit - IV

Application of infrared gas analyzer (IRGA) and chlorophyll florescence in plant physiology. Measurement of water potential, photosynthetic rate using infrared gas analyzer, and chlorophyll florescence (Fo, Fv, Fm, Fv/Fm ratio); Work principle of HPLC, UPLC, GC-MS, LC-MS, and their application in identification of biomolecules; Role of transcriptome analysis in deciphering the genes involved in plant stress response. Introduction to cDNA libraries and high through put sequencing techniques. Phenotyping, and abiotic stress.

Suggested Readings

1. Taiz L. and Zeiger E., 2003. Plant Physiology. Panima Publishing House, New Delhi.
2. Salisbury F. B and Ross C W., 2005. Plant Physiology. Thomson Asia Pte Ltd., Singapore.
3. Hopkins W. G. and Huner N. P., 2004. Introduction to Plant Physiology. John Wiley & Sons, Inc.
4. Moore T. C., 2000. Biochemistry and Physiology of Plant Hormones. Springer-Verlag, New York.
5. Nobel P. S., 2005. Physiochemical and Environmental Plant Physiology. Academic Press, San Diego, USA.
6. Alberts B., Johnson A., Lewis J., Morgan D., Raff M., Roberts K. and Walter P. 2014. Molecular Biology of the Cell. New York: Garland Science.

BOT(P) - 411(CBCP): Plant Stress Physiology (3 Credits)

1. Photosynthetic rate measurement using infrared gas analyser (visual demonstration)
2. Chlorophyll florescence measurement (visual demonstration)
3. Designing experiment to study the plant response to stress treatment
4. Measurement of relative water content, chlorophyll content, proline, lipid peroxidation, soluble sugar, secondary metabolite (antioxidant) content after stress treatment
5. Protein isolation from plant tissue.
6. Protein quantification and SDS-polyacrylamide gel electrophoresis of protein.
7. Antioxidant enzymes assay (catalase, ascorbate, glutathione reductase)
8. Alpha amylase activity in germinating seeds
9. Seasonal variations in the phenology of trees on the university campus

Suggested Readings (Also refer books suggested for theory paper):

1. Sadasivam S. and Manickam A., 2005. Biochemical Methods. New Age International (P) Lts., Publishers, India.
2. Hames B.D. (ed) 2004. Gel Electrophoresis of Proteins: A Practical Approach. PAS, Oxford University Press, Oxford, UK.
3. Plummer, D. T. 2000. An Introduction to Practical Biochemistry. Tata McGraw-Hill Publishing Co. Ltd., New Delhi.
4. Bajracharya, D. 1999. Experiments in Plant Physiology: A Laboratory Manual. Narosa Publishing House, New Delhi.
5. Dennison, C. 1999. A Guide to Protein Isolation. Kluwer Academic Publishers, Dordrecht, The Netherland.

Suggested Journals

1. Phytochemistry
2. Journal of Experimental Botany
3. Planta
4. Plant Physiology and Biochemistry
5. Journal of Plant Physiology
6. Plant Cell.

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BOT(T) – 412(CBCP): Microbial Applications in Agriculture and Environment (4 Credits)

Course Objectives and Expected Outcome: Through this course students should be able to describe the role of biofertilizer for sustainable agriculture practices. Students will gain knowledge about ecofriendly agricultural inputs for providing basis for large scale production. Besides this, they will be acquainted with the role of biofertilizers in crop improvement. These topics will facilitate to explore relation of biocontrol methods as integrated pest management approach for pest control.

Unit – I

General account of the microbes used as biofertilizers for various crop plants and their advantages over chemical fertilizers

Symbiotic Nitrogen Fixers: Rhizobium - Isolation, characteristics, types, inoculum production and field application, legume/pulses plants, Frankia - Isolation, characteristics, Alder, Casurina plants, non-leguminous crop symbiosis, Cyanobacteria, Azolla - Isolation, characterization, mass multiplication, Role in rice cultivation, Crop response, field application

Unit – II

Non-Symbiotic Nitrogen fixers: Free living Azospirillum, Azotobacter - free isolation, characteristics, mass inoculum production and field application

Phosphate Solubilizers: Phosphate solubilizing microbes - Isolation, characterization, mass inoculum production, field application

Mycorrhizal Biofertilizers: Importance of mycorrizal inoculum, types of mycorrhizae and associated plants, Mass inoculums production of VAM, field applications of Ectomycorrhizae and VAM

Unit – III

Bioinsecticides: General account of microbes used as bioinsecticides and their advantages over synthetic pesticides, Bacillus thuringiensis, production, Field applications, Viruses – cultivation and field applications

Unit – IV

Pest Management: Pest Management Methods, Biological Control, Botanics for Storage Pest Control, Cultural Practices/Ecological Methods, Plant resistance to pests, Practices for Pest Control, integrated pest management, resistance in pests

Suggested Readings

1. A Textbook of Biotechnology- Dubey, R.C., (2005) S. Chand & Co, New Delhi.
2. Biotechnology Kumaresan, V. (2005), Saras Publications, New Delhi.
3. Vermiculture and Organic Farming Sathe, T.V., (2004) Daya publishers.
4. Soil Microbiology Subha Rao, N.S. (2000), Oxford & IBH Publishers, New _Delhi.
5. Bio-fertilizers and organic Farming Vyas, S.C, Vayas, S. and Modi, H.A. (1998) Akta Prakashan, Nadiad
6. Biotechnology of Biofertilizers Kannaiyan, S., (2003), CHIPS, Texas.
7. Hand book of Microbial Biofertilizers Rai, M.K., (2005), The Haworth Press, Inc. NewYork

BOT(P) – 413(CBCP): Microbial Applications in Agriculture and Environment (3 Credits)

1. Isolation of free living Nitrogen fixing bacteria from soil
2. Isolation of symbiotic nitrogen fixing bacteria
3. Isolation of Cyanobacteria from soil
4. Isolation of phosphate solubilizing microorganisms from soil
5. Isolate and identification of mycorrhiza by wet sieving and decanting technique
6. Exploration of mycorrhizal association in plant roots

Suggested Readings

1. Prescott's Microbiology by Joanne M Willey, Linda Sherwood, Chris Woolverton, Mcgraw Hill Education
2. Experiments in Microbiology, Plant Pathology and Biotechnology By Aneja, K.R., New Age International
3. Microbiology A Laboratory Manual by J.G. Cappuccino, N. Sherman, Pearson

BOT (T) - 414 (CBCP): Reproductive Biology of Angiosperms (4 Credits)

Course Objectives and Expected Outcome: The paper contains different aspects of plant reproduction and their significance. Understanding the biology of plant reproduction is of immense practical importance for conservation of biodiversity. On completion of this course the students will understand the scope of reproductive biology and how reproductive success among angiosperms is dependent on the innate biology and immediate ecological condition of plants.

Unit I

Reproductive Biology: History and scope; Pollen Biology: Pollen wall structure, MGU (male germ unit) structure, Unique features: Pseudomonads, polyads, pollinia; Pollination: Agencies of pollination, Adaptation in pollen to suit pollination strategies, Pollen allergy and pollen calendar, Applied pollination.

Unit II

Pollen-pistil interaction, Fertilization, Sexual incompatibility, Recognition and rejection reaction, Methods to overcoming self-incompatibility, Male sterility and its application for crop improvement.

Unit III

Endosperm: Endosperm types, endosperm haustoria and their functions; embryo-endosperm relationship, Embryogenesis, Polyembryony, Apomixis, Somatic Embryogenesis and its Agri-horticultural importance.

Unit IV

Seed and Fruit: Morphology and development of seed coat, seed appendages, seed dispersal mechanisms, Seed dormancy and seed germination; Fruit development, Diversity of fruit types, fruit abortion in relation to resource allocation.

Suggested readings:

1. Bhojwani, S.S. and Bhatnagar, S.P. 2000. The embryology of angiosperms. (4th revised and enlarged edition) Vikas Publishing house, New Delhi.
2. Chaturvedi, S.K. and Shonali Chaturvedi, 2001. Biology of reproduction in angiosperms. Bioved research society, Allahabad
3. Faegri, K. and Van der Pijl, L. 1969. The principal of pollination ecology. Peragamon Press, Toronto.
4. Johri, B.M. (ed.) 1982. Experimental embryology of vascular plants. Narosa Publishing house, New Delhi.
5. Johri, B.M. (ed.) 1984. Embryology of angiosperms. Narosa Publishing house, New Delhi.
6. Maheshwari, P. 1950. An introduction to the embryology of angiosperms. Mcgraw Hill Book Co.
7. Pandey, A.K. 1997. Embryology of angiosperms. CBS publishers and distributors, New Delhi.
8. Proctor, M. and Yeo, P. 1973. The pollination of flowers. Collins, St. J. Place. London
9. Raghavan, V. 2000. Developmental Biology of Flowering Plants, Springer, Netherlands
10. Shivanna. K.R. 2003. Pollen biology and biotechnology. Oxford IBH, New Delhi
11. Singh, V., Pandey, P.C. and Jain, D. K. 2003. Embryology of Angiosperms. Rastogi Publications, Meerut.

BOT (P) - 415 (CBCP): Reproductive Biology of Angiosperms (3 Credits)

1. Study of anther wall layers in the transverse section of members of some common plant families
2. Examination of mode of anther dehiscence and collection of pollen grains for microscopic examination of locally available monocots and dicots.
3. Pollen in vitro germination methods: Hanging drop and sitting drop culture, suspension culture, surface culture.
4. Study of monosporic, bisporic and tetrasporic types of embryo-sac development through permanent slides.
5. Field study of pollination types and adaptation for various types of pollination in flowers.
6. Dissection of embryo and endosperm.

Suggested readings: As in BOT (T) - 416