

**Department of Botany  
Nagaland University  
Lumami 798 627**

**M. Sc. Syllabus-2023**

**(Approved by 37<sup>th</sup> Academic Council held on 12<sup>th</sup> December 2023)**

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 **85 Credits** for award of M. Sc. (Botany) degree. The credits earned shall have a **minimum of 74 credits by way of core courses offered** by the Department **and 7credits 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 80 Credits, student each student needs to earn **4 Credits through MOOCS Courses during the duration of M. Sc. courses and score will be reflected in the 4<sup>th</sup> 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 paper worth 3 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 (3 credits) in the 4<sup>th</sup> 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 150 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, 1 credit each will be on presentation of the project reports and report of the 'Academic Study Tour/Laboratory Visit/Internship' and 6 credits for project report/dissertation.

There will be three internal assessment tests per paper (both theory and practical separately) and one must appear in at least two 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 25 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)	Mycology, Plant Pathology and 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) - 205(C)	Plant Biochemistry and Molecular Biology	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 molecular biology which can be helpful of students to prepare for employment in 'Biochemical and molecular biology industries and related Government and private sectors.
BOT(T)-303(C)	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.
BOT(T)-305(C)	Plant Ecology and Ecosystem Analysis	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.
BOT(T)-410(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 Content

Course Code/Type	Course Title	Max. Marks	Credit	Page No.	
SEMESTER I	BOT(T)-101(C)	Lower Plants	100	4	
	BOT(P)-102(C)	Lower Plants	50	3	
	BOT(T)-103(C)	Mycology, Plant Pathology and Microbiology	100	4	
	BOT(P)-104(C)	Mycology, Plant Pathology and Microbiology	50	3	
	BOT(T)-105(C)	Angiosperm Taxonomy and Economic Botany	100	4	
	BOT(P)-106(C)	Angiosperm Taxonomy and Economic Botany	50	3	
	<b>TOTAL</b>	<b>450</b>	<b>21</b>		
SEMESTER II	BOT(T)-201(C)	Gymnosperms, Anatomy, Reproductive Biology and Embryology	100	4	
	BOT(P)-202(C)	Gymnosperms, Anatomy, Reproductive Biology and Embryology	50	3	
	BOT(T)-203(C)	Plant Physiology	100	4	
	BOT(P)-204(C)	Plant Physiology	50	3	
	BOT(T)-205(C)	Plant Biochemistry and Molecular Biology	100	4	
	BOT(P)-206(C)	Plant Biochemistry and Molecular Biology	50	3	
	<b>TOTAL</b>	<b>450</b>	<b>21</b>		
SEMESTER III	BOT(T)-301(C)	Cell Biology, Cytogenetics and Plant Breeding	100	4	
	BOT(P)-302(C)	Cell Biology, Cytogenetics and Plant Breeding	50	3	
	BOT(T)-303(C)	Plant Biotechnology	100	4	
	BOT(P)-304(C)	Plant Biotechnology	50	3	
	BOT(T)-305(C)	Plant Ecology and Ecosystem Analysis	100	4	
	BOT(P)-306(C)	Plant Ecology and Ecosystem Analysis	50	3	
	<b>TOTAL</b>	<b>450</b>	<b>21</b>		
SEMESTER IV	BOT(T)-401(C)	Biodiversity, Phytogeography, Biostatistics and Environment	100	4	
	BOT(P)-402(C)	Biodiversity, Phytogeography, Biostatistics and Environment	50	3	
	BOT(P)-403(C)	Project Work and Academic Study Tour*#	150	8	
	<b>Choice Based Credit Papers**</b>				
	BOT(T)-404(CBCP)	Angiosperm Taxonomy & Biosystematics	100	4	
	BOT(P)-405(CBCP)	Angiosperm Taxonomy & Biosystematics	50	3	
	BOT(T)-406(CBCP)	Biodiversity Conservation, Ecosystem Services and Ecological Restoration	100	4	
	BOT(P)-407(CBCP)	Biodiversity Conservation, Ecosystem Services and Ecological Restoration	50	3	
	BOT(T)-408(CBCP)	Microbial Studies	100	4	
	BOT(P)-409(CBCP)	Microbial Studies	50	3	
	BOT(T)-410(CBCP)	Plant Biotechnology	100	4	
	BOT(P)-411(CBCP)	Plant Biotechnology	50	3	
	BOT(T)-412(CBCP)	Plant Biochemistry and Physiology	100	4	
	BOT(P)-413(CBCP)	Plant Biochemistry and Physiology	50	3	
	BOT(T)-414(CBCP)	Microbial Applications in Agriculture and Environment	100	4	
	BOT(P)-415(CBCP)	Microbial Applications in Agriculture and Environment	50	3	
	BOT(T)-416(CBCP)	Reproductive Biology	100	4	
	BOT(P)-417(CBCP)	Reproductive Biology	50	3	
		<b>TOTAL</b>	<b>450</b>	<b>22</b>	
	BOT(T)-418(CBCP-M)	<b>MOOCS</b>	-	4	
	<b>GRAND TOTAL</b>	<b>1800</b>	<b>85</b>		

Abbreviations: BOT(T): Botany Theory, BOT(P): Botany Practical, C: Core; CBCP-M: Choice Based Credit Paper (MOOCS). CBCP: Choice Based Credit Paper. \* Broad areas of Project Work: Higher Plant Ecology, Biodiversity Conservation & Ecosystem analysis (Aquatic and terrestrial ecosystem), Phytogeography, Microbial Ecology, Food Fermentation, Plant Molecular Biology, Plant Physiology, Reproductive Biology, Seed Biology, Plant Biotechnology, Plant Genetics & Cytogenetics, Angiosperm Taxonomy, Ethnobotany, Lower plant etc. # Project work will be assigned in the 3rd Semester and evaluated in the 4th Semester. \*\* Students need to opt for one of the CBCS paper and its corresponding practical from the list given above.

**BOT(T) - 101(C): 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 psilophytosida, psilotosida, 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): 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).**

M. Sc. Botany Syllabus, Nagaland University

**BOT(T) - 103(C): Mycology, Plant Pathology and 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). 4<sup>th</sup> 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* (3<sup>rd</sup> 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* (2<sup>nd</sup> 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): Mycology, Plant Pathology and Microbiology (3 Credits)**

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

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

M. Sc. Botany Syllabus, Nagaland University

**BOT(T) - 105(C): Angiosperm 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 emphasised.

**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) Botanical Survey of India, its establishment and activities; 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, nomina conservanta.

**Unit - III**

Sources of Taxonomic Evidences: Embryology, palynology, vegetative and floral anatomy, cytology; Origin of angiosperms, time and place of origin, lines of evolution of angiosperms; 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](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)**

M. Sc. Botany Syllabus, Nagaland University

**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 Cordiales. 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 pollination 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* 2<sup>nd</sup> 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, embry sac 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 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**

Plant water relations, mechanism of water transport through xylem, xylem and phloem transport, phloem loading and unloading, passive and active transport; Structure and function of enzyme active site, regulation of enzyme activities, enzyme kinetics including Michaelis-Menten equation.

**Unit - II**

Photosynthesis (photo oxidation of water, cyclic and non-cyclic photophosphorylation, Calvin cycle, C<sub>3</sub>, C<sub>4</sub> and CAM pathways); Photorespiration; Different phases of respiration (Glycolysis, Citric acid cycle, ETC/ETS); cyanide resistant respiration/alternative oxidase system; Role of photoperiodism and phytochrome in flowering, vernalization; Mechanism of seed germination; Dormancy, Senescence, Acclimation.

**Unit III**

Pentose phosphate pathways (inter-conversion of hexoses and pentoses), Biological nitrogen fixation, structure and function of nitrogenase, mechanism of biological nitrogen fixation, mechanism of nitrate and ammonium assimilation; Overview of signal transduction, signal receptors, primary and secondary messengers, G-proteins, phospholipid signaling, cyclic nucleotides and calcium-calmodulin cascades.

**Unit - IV**

Introduction to abiotic and biotic stress: Phenotypic plasticity and plant adaptation; Plant responses to biotic and abiotic stresses; Introduction to developmental biology of plants, plant growth and development; Physiological effects, biosynthesis and mechanism of action of Auxins, Cytokinins, Abscisic acid, Gibberellins, Ethylene, Biological role of brassinosteroids, polyamines, TDZ.

**Suggested Readings**

1. Nelson D. L. and Cox M. M., 2005. Lehningers' Principles of Biochemistry (4<sup>th</sup> 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 (3<sup>rd</sup> edition). John Wiley and Sons Ltd., England.
3. Taiz L. and Zeiger E., 2003. Plant Physiology (3<sup>rd</sup> edition). Panima Publishing House, New Delhi.
4. Salisbury F. B and Ross C W., 2005. Plant Physiology (4<sup>th</sup> edition). Thomson Asia Pte Ltd., Singapore.
5. Hopkins W. G. and Huner N. P., 2004. Introduction to Plant Physiology (3<sup>rd</sup> edition). John Wiley & Sons, Inc.
6. Moore T. C., 2000. Biochemistry and Physiology of Plant Hormones (3<sup>rd</sup> edition). Springer-Verlag, New York.
7. Thomas B. and Vince-Prue, D. 2004. Photoperiodism in Plants (3<sup>rd</sup> edition). Academic Press San Diego, USA.
8. Nobel P. S., 2005. Physiochemical and Environmental Plant Physiology (3<sup>rd</sup> edition). Academic Press, San Diego, USA.
9. Raghavan, V. 1999. Developmental biology of flowering plants. Springer- Verlag, New York.
10. Alberts B., Johnson A., Lewis J., Morgan D., Raff M., Roberts K. and Walter P. 2014. Molecular Biology of the Cell. 6<sup>th</sup> edition. New York: Garland Science.

**BOT(P) - 204(C): Plant Physiology**

**(3 Credits)**

**Practical Exercises**

1. Effect of substrate concentration on enzyme activity and determination of its  $K_m$  value.
2. Effect of temperature and  $pH$  on enzyme activity.
3. Demonstration of substrate inducibility of the enzyme nitrate reductase.
4. Extraction of different photosynthetic pigments and preparation of their absorption spectra.
5. Quantification of Chlorophyll *a*, *b* in  $C_3$  and  $C_4$  plants and their ratio.
6. Study the effects of light quality and intensity on Hill reaction.
7. Assay of amylase induction by GA in plant tissue.
8. 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 (4<sup>th</sup> edition). New Age International (P) Lts., Publishers, India.
3. Dennison, C. 1999. A Guide to Protein Isolation. Kluwer Academic Publishers, Dordrecht, The Netherland.
4. Hames B. D. (ed) 2004. Gel Electrophoresis of Proteins: A Practical Approach (4<sup>th</sup> edition). PAS, Oxford University Press, Oxford, UK.
5. 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(P) - 205(C): Plant Biochemistry and Molecular Biology (4 Credits)**

**Objectives:** 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 molecular biology 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; Biosynthesis of glucose, sucrose, starch and cellulose; Biosynthesis of fatty acid and  $\beta$ -oxidation.

**Unit-II**

Structural organization of plant cell, structure and function of cell wall, plasma membrane; cytoskeleton; Ion pumps of plasma membrane; Chloroplast and mitochondria genome organization and gene expression; Structure and function of tonoplast membrane, golgi apparatus, endoplasmic reticulum.

**Unit-III**

Structure and function of nucleus, nucleosome organization, Diversity in DNA and RNA structures; DNA replication, DNA damage and repair; Pro and eukaryotic transcription, plant promoters and transcription factors; mRNA processing.

**Unit-IV**

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 E<sub>2</sub>F proteins on cell cycle; Mechanisms of programmed cell death; Oncogenes.

**Suggested Readings**

1. Nelson D. L. and Cox M. M., 2005. Lehningers' Principles of Biochemistry (4<sup>th</sup> 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 (3<sup>rd</sup> edition). John Wiley and Sons Ltd., England.
3. Lewin, B, 2008. Genes IX. Oxford University Press, New York.
4. Buchanan B. B., Gruissem W. and Jones R. L., 2000. Biochemistry and Molecular biology of Plants. American Society of Plant Physiologists, Maryland, USA.
5. De Robertis E. D. P. and De Robertis E. M. F. Jr., 2006). Cell and Molecular Biology (10<sup>th</sup> edition). B. I. Waverly Pvt. Ltd., New Delhi.
6. Zubay G L., Parson W. W. and Vance D. E. 2000. Principles of Biochemistry. Wm. C. Brown Publishers, Oxford, England.
7. 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.

**BOT(P) - 206(C): Plant Biochemistry and Molecular Biology (3 Credits)**

1. Estimation of reducing sugar.
2. Estimation of amino acids.
3. Estimation of protein by Lowry's or Bradford's method.
4. SDS-PAGE for soluble proteins extracted from the given plant materials and comparison of their profile by staining with *Coomassie Brilliant Blue*.
5. Quantification of DNA by spectrophotometric method.
6. Quantification of RNA by spectrophotometric method.
7. Isolation and purification of plant DNA.
8. Isolation and purification of plant RNAs.
9. Isolation of plasmid.

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

1. Glick B. R. and Thompsom J. E. 1993. *Methods in Molecular Biology and Biotechnology*. CRC Press, Boca Raton, Florida.
2. Singh B. D., 2005. *Biotechnology*. Kalyani publishers, New Delhi, India.
3. Gunning B. E. S. and Steer M. W., 2004. *Plant Cell Biology: Structure and Function*. Jones and Bartlett Publishers, Boston, Massachusetts.
4. Hall J. L. and Moore A. L., 1993. *Isolation of Membranes and Organelles from Plant Cells*. Academic Press, London, UK.
5. Sadasivam S. and Manickam A., 2005. *Biochemical Methods* (4<sup>th</sup> edition). New Age International (P) Lts., Publishers, India.
6. Hames B. D. (ed) 2004. *Gel Electrophoresis of Proteins: A Practical Approach* (4<sup>th</sup> edition). PAS, Oxford University Press, Oxford, UK.
7. Plummer, D. T. 2000. *An Introduction to Practical Biochemistry*. Tata McGraw-Hill Publishing Co. Ltd., New Delhi.

**BOT(T) - 301(C): Cell Biology, Cytogenetics and Plant Breeding (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 role in plant breeding.

**Unit - I**

Structural organization of plant cell, structure and function of cell wall, plasma membrane; cytoskeleton; Ion pumps of plasma membrane; 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,

**Unit - II**

Gene-modern concept, split gene, overlapping genes, gene clusters and repeats, C-value paradox, Cot value, Nucleosome assembly, packing of DNA into chromosomes, Chromosome types, Nucleolus, RNAs, B-chromosomes, Genetic code, operon model and regulatory circuits, transposons.

**Unit - III**

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, mutation, recombination in bacteria, conjugation and transduction.

**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(P) - 302(C): Cell Biology, Cytogenetics and Plant Breeding (3 Credits)**

1. Probability and chi-square test for genetic analyses.
2. Preparation of karyotype and ideogram.
3. Preparation of metaphase slide from suitable plant material.
4. Study of different mitotic stages from suitable plant material.
5. Study of meiosis.

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

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**BOT(T) - 303(C): 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.

**Unit - I**

Biotechnology: Concepts, definitions, principles and scope; Cellular totipotency; Micropropagation and techniques; plant tissue culture media, plant growth regulators in tissue culture and problems associated with plant tissue culture; Somatic embryogenesis, artificial seed production; Production of virus-free plants; Embryo rescue.

**Unit - II**

Haploid production in culture and application; Protoplast isolation, purification, somatic hybridization, cybridization, application and limitation of protoplast research; Somaclonal variation and its application; Production of commercially useful secondary metabolites in culture; Conservation of germplasms *in vitro*- 'slow growth technique, and cryopreservation.

**Unit - III**

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), PCR.

**Unit - IV**

Environmental biotechnology; Fermentation Technology: Concepts, definitions and techniques of fermentation technology; Genetic and physical mapping of genes; artificial chromosome, Bioinformatics tools; Genomics, and Proteomics, Intellectual property right.

**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 (2<sup>nd</sup> edition). Academic Press.

**BOT(P) - 304(C): Plant Biotechnology**

**(3 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. Demonstration of protoplast isolation and culture.
8. Demonstration of cryopreservation.
9. Isolation of DNA and agarose gel electrophoresis.
10. PCR

**Suggested Readings: As in BOT(T) -303(C).**

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

**Suggested Journals**

1. Plant Cell
2. Plant Journal
3. Plant Biotechnology Journal
4. Plant Organ Tissue Culture
5. Plant Cell Reports
6. Plant Physiology
7. Transgenic Research

**BOT(T) - 305(C): Plant Ecology and Ecosystem Analysis****(4 Credits)**

**Objectives:** To understand the fundamentals of plant ecology, 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**

Scope of Ecology; Concept pertaining to limiting factors, Triggering factors, Environmental factors (Soil, Water, Light, Temperature & Fire) and interactions with biotic factors.

**Unit - II**

Population Ecology; Population growth; Survivorship curve, life table analysis and age structured populations; Population dynamics and Plant population regulation, Population interactions and allelopathy: Ecotypes, Ecocline, Ecological Niche; Life history strategies (*r* and *k* strategies).

**Unit - III**

Community Ecology: Concepts of community and continuum; Community Structure- Life form and biological spectrum, species diversity and dominance; Analytical and synthetic characters of communities; Mechanism of ecological succession; facilitation, tolerance and inhibition models); Changes in ecosystem properties during Succession. Concept of climax community.

**Unit - IV**

Ecosystem Ecology; Ecosystem structure and function of some major ecosystem of the world; Forest, Grassland, Desert, Mountains, Freshwater and Marine Ecosystems, Mangroves and Coral reefs ecosystems; Primary productivity and its measurement; Energy flow pathways; Nutrient dynamics in ecosystems

**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.

**BOT(P) - 306(C): Plant Ecology and Ecosystem Analysis (3 Credits)**

1. Study of the Interactions between Plants and Environment:
  - (i) Study of micro climatic conditions in open and closed communities.
  - (ii) Study of plastic response of plants species under contrasting environmental condition.
2. Study of soil profile.
3. Study of the physico-chemical properties of soil: soil temperature, soil pH, Porosity, bulk density, Texture, Water holding capacity, chemical properties of soil by Rapid Spot Test.
4. Estimation of phytomass and its distribution in different above and below ground compartments.
5. To determine the Leaf Area Index (LAI), Leaf area of the dominant plant species.
6. To determine primary productivity of plant community by-
  - (i). Harvest Method.
  - (ii). Light and Dark bottle Method.

**Suggested Readings**

1. Misra, R. (1968). Ecology Workbook. Oxford & IBH.
2. Muller dombois and Ellenberg H. (1974). Aims and methods of Vegetation Ecology. John Wiley & Sons.
3. Smith, R.L. (1996). Ecology and Field Biology. Harper Collins, New York.
4. Pielou, E.C. (1984). The Interpretation of Ecological Data. Wiley, New York.
5. Magurran, A.E. (1988). Ecological Diversity and its Measurement. Chapman & Hall, London.

**BOT(T) - 401(C): Biodiversity, Phytogeography, Biostatistics and Environment (4 Credits)**

**Objectives: To gain understanding of the status of the world's biodiversity, value and drivers of its loss. 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.**

**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's of plant diversity ; Status of plant diversity conservation in India; Strategies for conservation, CBD, Biodiversity Act, Biodiversity information system.

**Unit - II**

Phytogeography: Static and interpretive plant geography; phytogeographic regions of India; Altitudinal zonation of vegetation on the Eastern and Western Himalayas; Plant migration and barrier of plant distribution, Endemism.

**Unit - III**

Climate Change and Ecosystem resilience: Resilience, Restoration and stability of Ecosystems. Environmental Pollution: Air, Water and Soil pollution and its effects on plants and ecosystems; Changes in water quality due to sewage, industrial effluents, effects on phytoplankton productivity, Impact of Climate Change on ecosystem, agriculture and food security; Bioremediation/Phytoremediation, Biomagnifications; Biomonitoring and Bioindicator; Carbon Sequestration, Pollution monitoring bodies.

**Unit - IV**

Application and uses of Biostatistics, frequency distributions and their descriptive statistics (mean, variance, coefficient of variation, correlation etc.) use of SD, SE, Coefficient of variation, variability and their types,); experimental design and hypothesis testing: Concept of P value; Test statistics like t-test (paired and unpaired) and Chi square ( $\chi^2$ ) or  $Z^2$ -test; basics of linear Regression and ANOVA or F-test.

**Suggested Readings**

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

**BOT(P) - 402(C): Biodiversity, Phytogeography, Biostatistics and Environment (3 Credits)**

1. Biodiversity assessment of forest tree community.
2. Field visit to forest - data collection and report preparation.
3. Determination of free carbon dioxide, Dissolved oxygen (DO), Biological oxygen demand (BOD), pH, Chloride, Conductivity, Total dissolved Solid (TDS) and Total hardness from the water samples.
4. To solve the Biostatistics Problems based on theoretical topics.

**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. Dutta, N.K. (2002). Fundamentals of Biostatistics, Practical Approach, Kanishka Publishers distributors, New Delhi-110002
4. Gupta, S. P. (2011). Statistical Methods, 40<sup>th</sup> first revised edition, Sultan Chand and Sons, Darya Ganj, New Delhi-110002
5. Ramakrishanan, P. (1996). Biostatistics, Soras Publication, Kanyakumari. Nagercoil- 2
6. Anne, E. Magurran. (1988). Ecological Diversity and its Measurement. Chapman and Hall, New York.

**BOT(P) - 403(C): Project Work and Academic Study Tour (8 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 3<sup>rd</sup> Semester and 'Dissertation' will be evaluated at the end of 4<sup>th</sup> Semester for 7 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 students need to undertake 7-10 days 'Academic Study Tour', 'Internship' of at least 7 working days from any Institute/Industry or Industrial Visit of students' choice. The 'Study Tour/Internship/Industrial Visit' will carry 01 credit. On completion of the tour / 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, Academic Study Tour/ Internship cannot be conducted by the University/Department, 'Dissertation' will be evaluated for 07 credits.

**BOT(T) - 404(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, importance of herbaria in botanical research, 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; Introduction to DELTA and its application to classification and identification.

**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, taxometrics, 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. 1995). 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) - 405(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).**

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**BOT(T) - 406(CBCP): Biodiversity Conservation, Ecosystem Services and Ecological Restoration (4 Credits)**

**Objectives:** To gain an understanding of (i) basic concepts and scientific principles of conservation and global patterns in biodiversity (ii) value and different services provided by ecosystems. Current efforts to conserve biodiversity at global, national and local scales.

**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; *In-situ* and *ex-situ* conservation, Global protected area network, , National Biodiversity Authority. India - Biosphere reserves, Principles of Biodiversity conservation; 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**

Ecosystem services: concept of ecosystem services, Economic valuation of ecosystem services; Ecological Restoration: concept and scope of restoration, restoration of degraded forest; Ecosystem Stability: concept of resistance, resilience and homeostasis; Ecological perturbation-natural and anthropogenic and their impact on plant and ecosystems.

**Unit - IV**

Forest and Freshwater Ecosystem Function; Distribution, forest structure, composition, component interactions, human impacts and conservation. Methods of measurement of productivity patterns, Forest cover of India with special reference to North-East India, Economic value of forest resources. Freshwater Ecosystem Function and Management: Classification of freshwater ecosystems; Structure, energy flow and productivity in freshwater ecosystems; Limiting factors, influence of light, temperature and chemicals in freshwater ecosystem; Management of freshwater bodies.

**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. (3<sup>rd</sup> 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.
9. Lampert, W and Sommer, U. (2007). Limno Ecology. (2<sup>nd</sup> edition). Oxford University Press.
10. Barnes, B.V., Zak, D R., Denton, S.R and Spurr, S.R. (1998). Forest Ecology. (4<sup>th</sup> edition). John Wiley and Sons.

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

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**BOT(P) - 407(CBCP):Biodiversity Conservation, Ecosystem Services and Ecological Restoration (3 Credits)**

1. Study of species diversity and dominance 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. To determine the soil respiration.
5. Determination of the physico-chemical properties of water: pH, temperature, TDS, conductivity, Free Carbondioxide, Dissolved Oxygen, BOD, Total alkalinity, Total hardness, Ca and Mg hardness, Chloride.
6. Determination of Soil Organic Carbon and Organic matter content.

**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. APHA. (2005). American Public Health Association, Standard Methods for the Examination of Water and Wastewater, Method 1020.
5. Jackson, M.L. (1973). Soil Chemical Analysis. Prentice Hall of India Pvt. Ltd., New Delhi (India).
6. Trivedy, R. K. and Goel P. K. (1986). Chemical and Biological methods for Water Pollution Studies. Environmental Publication, Karad, Maharashtra.

**BOT(T) - 408(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 (4<sup>th</sup> edition). Benjamin/Cummings Science Publication.

**BOT(P) - 409(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.**

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**BOT(T) - 410(CBCP): Plant Biotechnology****(4 Credits)**

**Objectives: The use different emerging technologies/tools in biological science is necessary for human welfare and security of the world. This paper deals with different biological processes and different modern techniques in the field of biotechnology with reference to plants.**

**Unit - I**

Biotechnology: Concepts, definitions, principles and scope; Micropropagation techniques; Organ culture; Somatic embryogenesis and application; Haploid production and application; Protoplast isolation, purification, somatic hybridization, cybridization.

**Unit - II**

Production of useful secondary metabolites in culture (use of bioreactors and immobilized cell culture); somaclonal and gametoclonal variation and its application; Role of biotechnology in conservation of PGRs (*in vitro* mass multiplication of plants, long-term preservation of germplasm through cryopreservation; Industrial microbiology (fermentation technology).

**Unit - III**

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, Triple helix DNA.

**Unit - IV**

Environmental Biotechnology; Metagenomics; Introduction to Nanobiotechnology; Ethical issues; Biotechnology and biosafety; Basic DNA sequence technique; Introduction to Bioinformatics and databases (Biological databases, Nucleic acid data bases, protein data bases, Specialized genome data bases, Structure data bases).

**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. Birkhauser 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 (2<sup>nd</sup> edition). Academic Press.

M. Sc. Botany Syllabus, Nagaland University

**BOT(P) - 411(CBCP): Plant Biotechnology**

**(3 Credits)**

1. Micropropagation of economically important local plants through organ culture.
2. Induction of somatic embryogenesis.
3. Protoplast isolation and culture and protoplast fusion.
4. Cryopreservation of germplasm.
5. Isolation of DNA and agarose gel electrophoresis & PCR
6. Demonstration for preparation of competent cells and transformation of *E. coli*.
7. Plasmid DNA isolation, quantification and agarose gel electrophoresis.
8. RNA isolation, quantification and gel electrophoresis.

**Suggested Readings as in BOT(T) - 408(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 of Plants, 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) - 412(CBCP): 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**

Biosynthesis of amino acids and molecules derived from amino acids; Biosynthesis of glutathione and biological amines from amino acids.

**Unit - II**

Plant responses to biotic and abiotic stresses (physiological, biochemical, cellular and molecular levels), role of plant hormones in stress response, plant stress and reactive oxygen species, photo-oxidative damage, stress mitigation mechanism in plants (antioxidant and enzymatic), Asada-Halliwell pathway.

**Unit III**

Classes of plant secondary metabolites; Secondary metabolite metabolism and biogenesis; Secondary metabolite flux; Biological properties and ecological significance; Synthetic biology approach for secondary metabolite synthesis.

**Unit - IV**

Measurement of photosynthetic rate using infrared gas analyzer; Chlorophyll fluorescence measurement ( $F_o$ ,  $F_v$ ,  $F_m$ ,  $F_v/F_m$  ratio); Extraction of metabolites and high performance liquid chromatography in separation of biomolecules; Radioisotopes in elucidation of biochemical pathways. Role of transcriptome analysis in deciphering the genes involved in secondary metabolite synthesis.

**Suggested Readings**

1. Goodwin and Mercer, 2005. Introduction to Plant Biochemistry, edition 2, CBS Publishers & Distributors.
2. J.B. Harborne, 1973. Phytochemical Methods, 2<sup>nd</sup> edition, Chapman & Hall Publishers.
3. K. Wilson and J. Walker, eds. 2000. Practical Biochemistry, 5<sup>th</sup> edition, Cambridge University Press.
4. D.J. Holme and H. Peck, 3<sup>rd</sup> edition 1998. Analytical Biochemistry, Longman Publishers.
5. Nelson D. L. and Cox M. M., 2005. Lehningers' Principles of Biochemistry (4<sup>th</sup> Edition). W. H. Freeman and Company, 41 Madison Avenue, New York, NY 10010.
7. Taiz L. and Zeiger E., 2003. Plant Physiology (3<sup>rd</sup> edition). Panima Publishing House, New Delhi.
8. Salisbury F. B and Ross C W., 2005. Plant Physiology (4<sup>th</sup> edition). Thomson Asia Pte Ltd., Singapore.
9. Hopkins W. G. and Huner N. P., 2004. Introduction to Plant Physiology (3<sup>rd</sup> edition). John Wiley & Sons, Inc.
10. Moore T. C., 2000. Biochemistry and Physiology of Plant Hormones (3<sup>rd</sup> edition). Springer-Verlag, New York.
11. Nobel P. S., 2005. Physiochemical and Environmental Plant Physiology (3<sup>rd</sup> edition). Academic Press, San Diego, USA.
12. Alberts B., Johnson A., Lewis J., Morgan D., Raff M., Roberts K. and Walter P. 2014. Molecular Biology of the Cell. 6<sup>th</sup> edition. New York: Garland Science.

**BOT(P) - 413(CBCP): Plant Biochemistry and Physiology**

**(3 Credits)**

1. Protein isolation from plant tissue.
2. SDS-polyacrylamide gel electrophoresis of protein.
3. Antioxidant enzymes assay (catalase, ascorbate, glutathione reductase)
4. Extraction and estimation of plant secondary metabolites.

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

1. Sadasivam S. and Manickam A., 2005. Biochemical Methods (4<sup>th</sup> edition). New Age International (P) Lts., Publishers, India.
2. Hames B.D. (ed) 2004. Gel Electrophoresis of Proteins: A Practical Approach (4<sup>th</sup> edition). 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) – 414(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 mycorrhizal 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, Botanicals 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. New York

**BOT(P) – 415(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) - 416 (CBCP): Reproductive Biology****(4 Credits)**

**Course Objectives and Expected Outcome:** The paper contains different aspects of plant reproduction and their significance. Understanding plant reproduction is of immense practical importance for conservation of biodiversity. On completion of this course the students will be able to discuss pollination biology, pollen-pistil interaction, fertilization, sexual incompatibility, embryogenesis, polyembryony, apomixis, seed and fruit development. This knowledge will help to apply in agriculture for production of hybrids, understand the pollen allergy problems in humans and conservation of endangered plants.

**Unit I**

Pollination: Agencies of pollination, Adaptation in pollen to suit pollination strategies, Applied pollination, Pollen allergy and pollen calendar, Male sterility, Molecular basis of male sterility, Uses of male sterility in plant breeding.

**Unit II**

Pollen- pistil interaction, significance, role of pollen wall proteins and stigma surface proteins, Recognition and rejection, Physiological and ultrastructural studies on pollen tube growth in pistil, Fertilization, Sexual incompatibility, Mechanism of inter-specific incompatibility, Methods of overcoming incompatibilities.

**Unit III**

Endosperm and its role in embryo development, Embryogenesis, Storage proteins of endosperm and embryo, Polyembryony, Embryo culture, Apomixis, somatic embryogenesis and its agricultural importance.

**Unit IV**

Seed and fruit: Physiology and growth of seed and fruit development, Morphology and development of seed coat, Seed dormancy and seed germination, Biochemistry and molecular biology of fruit maturation.

**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) - 417 (CBCP): Reproductive Biology**

**(3 Credits)**

1. Study of microsporogenesis and gametogenesis in section of anther.
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**