ST. JOSEPH'S COLLEGE (AUTONOMOUS)

BENGALURU-27

Re-accredited with **'A++' GRADE with 3.79/4 CGPA** by NAAC Recognized by UGC as College of Excellence

DEPARTMENT OF BOTANY

SYLLABUS FOR POSTGRADUATE PROGRAMME

For Batch 2021-2023

Part B

M.Sc. Botany Curriculum

Courses and course completion requirements	No. of credits
Botany	94
Open elective courses (non-professional)	
Outreach activity	

SUMMARY OF CREDITS

DEPARTMENT OF BOTANY (PG) (2021-2023)								
Semester 1	**Code Number**	**Title**	**No. of Hours of Instructions**	**Number of Hours of teaching per week**	**Number of credits**	**Continuous Internal Assessment (CIA) Marks**	**End Semester Marks**	**Total marks**
Theory	BO 7121	Microbiology, Mycology and Plant Pathology	60	04	04	30	70	100
Theory	BO 7221	Algae and Bryophytes	60	04	04	30	70	100
Theory	BO 7321	Paleobotany, Palynology and Plant Anatomy	60	04	04	30	70	100
Theory	BO 7421	Biostatistics and Bioinformatics	60	04	04	30	70	100
Practical	BO 7P1	Microbiology, Mycology and Plant Pathology	44	04	02	15	35	50
Practical	BO 7P2	Algae and Bryophytes	44	04	02	15	35	50
Practical	BO 7P3	Paleobotany, Palynology and Plant Anatomy	44	04	02	15	35	50
Practical	BO 7P4	Biostatistics and Bioinformatics	44	04	02	15	35	50
Total Number of credits:			**24**					
Semester 2	**Code Number**	**Title**	**No. of Hours of Instructions**	**Number of teaching hrs /week**	**Number of credits**	**Continuous Internal Assessment (CIA) Marks**	**End Semester Marks**	**Total marks**
Theory	BO 8121	Pteridophytes and Gymnosperms	60	04	04	30	70	100
Theory	BO 8221	Plant morphogenesis and Embryology	60	04	04	30	70	100
Theory	BO 8321	Plant Physiology and Metabolism	60	04	04	30	70	100
Theory	BO 8421	Methods in Plant Sciences	60	04	04	30	70	100
Practical	BO 8P1	Pteridophytes and Gymnosperms	44	04	02	15	35	50
Practical	BO 8P2	Plant morphogenesis and Embryology	44	04	02	15	35	50
Practical	BO 8P3	Plant Physiology and Metabolism	44	04	02	15	35	50

Practical	BO 8P4	Methods in Plant Sciences	44	04	02	15	35	50
Total Number of credits:			**24**					
Semester 3	**Code Number**	**Title**	**No. of Hours of Instructions**	**Number of teaching hrs /week**	**Number of credits**	**Continuous Internal Assessment (CIA) Marks**	**End Semester Marks**	**Total marks**
Theory	BO 9121	Taxonomy of Angiosperms and Economic Botany	60	04	04	30	70	100
Theory	BO 9221	Ecology and Environmental Biology	60	04	04	30	70	100
Theory (DE)	BODE 9321	Advanced Physiology (Elective)	60	05	04	30	70	100
Theory (DE)	BODE 9421	Plant Tissue Culture (Elective)	60	05	04	30	70	100
Note: Students can choose one of the departmental electives from BODE 9321 or BODE 9421								
Theory (OE)	BOOE 9521	Horticulture (Interdepartmental Elective)	30	04	02	15	35	50
Note: Students choose open elective from other departments.								
Practical	BO 9P1	Taxonomy of Angiosperms and Economic Botany	44	04	02	15	35	50
Practical	BO 9P2	Ecology and Environmental Biology	44	04	02	15	35	50
Practical	BO 9P3	Advanced Physiology (Elective)	44 + 44	04 + 04	02 + 02	15	35	50
Practical	BO 9P4	Plant Tissue Culture (Elective)	44 + 44	04 + 04	02 + 02	15	35	50
Total Number of credits:			**20**					
Theory	BO 0121	Cytology, Genetics and Molecular Biology	60	04	04	30	70	100
Theory	BO 0221	Biotechnology	60	04	04	30	70	100
Theory	BO 0321	Plant Breeding and Plant Propagation	60	04	04	30	70	100
Theory (DE)	BODE 0421	Microbiology (Elective)	60	05	04	30	70	100
Theory (DE)	BODE 0521	Systematics of Angiosperms (Elective)	60	05	04	30	70	100
Note: Students can choose one of the departmental electives from BODE 0421 or BODE 0521								

Practical	BO 10P1	Cytology, Genetics and Molecular Biology	44	04	02	15	35	50
Practical	BO 10P2	Biotechnology	44	04	02	15	35	50
Practical	BO 10P3	Plant Breeding and Plant Propagation	44	04	02	15	35	50
Practical	BO 10P4	Microbiology (Elective)	44 + 44	04 + 04	02 + 02	15	35	50
Practical	BO 10P5	Systematics of Angiosperms (Elective)	44 + 44	04 + 04	02 + 02	15	35	50
		IGNITORS/ OUTREACH						
Total Number of credits:			**26**					
Total No. of Credits : 94								
KEY WORDS: DE – Departmental Elective and OE – Open Elective								

CORE COURSES (CC)	
Course Title	Code Number
Microbiology, Mycology & Plant Pathology	**BO 7121**
Algae and Bryophytes	**BO 7221**
Paleobotany, Palynology and Plant Anatomy	**BO 7321**
Biostatistics and Bioinformatics	**BO 7421**

DISCIPLINE SPECIFIC ELECTIVE COURSES (DSE)	
Course Title	Code Number
Advanced Physiology	**BODE 9321**
Plant Tissue Culture	**BODE 9421**
Microbiology	**BODE 0418**
Systematics of Angiosperms	**BODE 0518**

GENERIC ELECTIVE COURSES (GSE)/ Can include open Electives offered	
Course Title	Code Number
Horticulture	**BOOE 9518**

SKILL ENHANCEMENT COURSE (SEC) – Any practical oriented and software based courses offered by departments to be listed below	
Course Title	Code Number
Plant Tissue Culture	BO 9P4
Biostatistics & Bioinformatics	BO 7421
Systematics of Angiosperms	BO 0518

VALUE ADDED COURSES (VAC) Certificate courses that add value to the core papers can be listed.	
Course Title	Code Number
Bioinformatics	
SAS programming	
Clinical Research and Management	
Microbiology	BO 0418
Systematics of Angiosperms	BO 0518

Online courses offered or recommended by the department to be listed	
Course Title	Code Number

Course Outcomes and Course Content

Semester	I
Paper Code	**BO 7121**
Paper Title	**Microbiology, Mycology and Plant Pathology**
Number of teaching hours per week	04
Total number of teaching hours per semester	60
Number of credits	04

Objective of the Paper:

To study and understand microbial diversity and their significance
To study and understand microbial diversity and their significance
To learn different techniques in Microbial studies
To understand identification, classification and naming of microbes
To understand the differences between beneficial and harmful microbes
To understand the diversity of plant diseases, symptoms, pathogens and their control

Unit I

Introduction to Microbiology — 12 hrs

Virus — **4 hrs**

Introduction
Classification of Viruses: ICTV and Baltimore system
Methods of cultivation and purification of viruses
Viral Capsomeres & Envelope

Bacteria — **6 + 2 hrs**

Classification of Bacteria
Bergey's Manual of Determinative and Systematic Bacteriology
Gram Positive & Gram Negative Cell Wall
Mycobacterial Cell Wall, Mycoplasmal Cell Covering
Classification of bacteria based on DNA-DNA hybridization & 16s rRNA sequencing
Construction of phylogenetic tree
Staining techniques for Bacteria - Simple, Differential, Structural Staining (Endospore, Capsule & Flagella)
Immunostaining
Culture Methods: Media - General, Specialized & Enrichment Media (self study)

Unit II

Diseases & Defence — 18 hrs

Host Pathogen Interaction — **7 + 2 hrs**

Infection Patterns; Pathogenicity; Virulence
Classification of Diseases (Epidemic, Endemic, Pandemic & Sporadic)

Disease Prognosis: Signs, Symptoms & Syndromes (self study)
Epidemiology
Diseases in Population
Reservoirs of Infection
Mode of Disease Transmission; Herd Immunity,
Nosocomial Infections
Control of Diseases: Vaccines, Toxoids.

Immune System **9 hrs**

Introduction to immunology
Innate & Acquired Immune Response
Antigen; Antibody Structure, Types & Properties
Haematopoiesis
Cells involved in immune system
Cell mediated & Humoral mediated immune reaction

Unit III

Mycology 15 hrs

Introduction to Mycology **13 + 2 hrs**

Characteristics; Habit; Habitat; Somatic Structures, & Reproduction of Fungi
Classification of fungi (Ainsworth, 1973, Alexopoulos et. al. 1996)
Phylogenetic classification of fungi (Mclaughlin et. al. 2001, Hibbett et. al. 2007 & Kirk et. al. 2008)
Salient Features; Criteria for Classification & Life Cycles of Myxomycota, Mastigomycotina, Zygomycotina, Ascomycotina, Basidiomycotina and Deuteromycotina.
Sex Hormones; Heterothallism & Parasexuality in Fungi
Brief account on Mycochemicals & Mycotoxins
*Economic importance of fungi - **(Self Study)***

Unit IV

Plant Pathology 15 hrs

Introduction to Plant Diseases **13 + 2 hrs**

History, Concepts & Scope of plant pathology
Classification of Plant Diseases
Disease Cycle; Disease Development; Pathogenicity test and Koch's postulates
Effect on Physiology of Host
Defense Mechanisms in Plants
Plant Disease Epidemics, Indexing & Disease Fore-Casting
Methods of Plant Disease Management
Study of Plant Diseases: (Etiology, Symptoms, Vectors, Disease Cycle & Control measures)
Mycoplasma Diseases: Grassy shoot of Sugar cane & Sandal wood spike
Viral Diseases: Bunchy top of Banana & Cotton leaf curl disease
Bacterial Diseases: Bacterial leaf blight of Paddy & Black rot of Crucifers,
Fungal Diseases: Coffee rust, Smut of Maize & Downy Mildew of Grapes
(Any of the above 2 diseases can be given as self study)

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5. Conrat F H, Kimball P C and Jay L, 1988. Virology, Prentice Hall, Englewood Cliff, New Jersey.
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10. Prescott M L, Harley J P and Klein D A. 1990. Microbiology, Wm C Brown publisher's, USA.
11. Schlegel H G, 1993. General Microbiology, 7th edition Cambridge University Press Cambridge, UK.
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20. Madigan, Mortinko and Parker (2000), Brock Biology of Microorganisms: Prentice Hall.
21. Wagner, E.K., and Hewlett, M.J. 2004. Basic Virology. Blackwell Science Ltd. II Edition, USA.
22. Khan J.A. and J. Dijkstra. 2002. Plant Viruses as Molecular Pathogens. Food Products Pres, NY.
23. Rangaswamy G and A. Mahadevan, 2002. Diseases of crop plants in India, Prentice Hall of India Pvt. Ltd. New Delhi.
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25. Arora, D. R. 2004. Textbook of Microbiology, CBS, New Delhi.
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27. Vasanthkumari, R. 2007. A textbook of Microbiology, BI Publications Pvt. Ltd., New Delhi.

BLUE PRINT

Code number: **BO 7121**

Title of the paper: **Microbiology, Mycology and Plant Pathology**

Total marks for which the questions are to be asked (including bonus questions)	Number of hours	Unit Number
19	12	I
29	18	II
24	15	III
24	15	IV
96	**60**	**TOTAL**
Maximum marks for the paper (Excluding bonus question): **70**		

BO 7P1: Microbiology, Mycology and Plant Pathology

Total: 44 hours

1. Micrometry
2. Haemocytometer
3. Isolation, Culture and Staining of Bacteria
4. Isolation, Culture and Staining of Fungi
5. Identification of Fungi using Fungal Floras
6. Type Study: *Stemonites, Synchytrium, Saprolegnia, Albugo, Phytophthora, Mucor , Erysiphe, Aspergillus, Chaetomium, Pencillium, Morchella, Hemileia, Ustilago, Lycoperdon, Cyathes, Dictyophora, Trichoderma, Curvularia, Alternaria, Fusarium, Pestalotia, Pleurotus, Polyporus & Ganoderma*. (use Alexopolus et.al., classification)
7. Study of Viral, Mycoplasmal, Bacterial & Fungal Diseases in Plants. (*based on availability two each*)

REFERENCES:

1. Aneja, K.R. 1993. Experiments in Microbiology, plant pathology and tissue culture, Wishwa Prakashan, New Delhi.
2. Pelczar, M.J. (Jr.) Chan, E.C.S. and Kreig, N.R. 1988. Microbiology, 5th edition McGraw Hall book company, Singapore.
3. Schlegel, H.G. 1993. General Microbiology, 7th edition Cambridge University Press Cambridge, UK.
4. Webster. J. 1980. Introduction to Fungi. Cambridge Univ.Press, UK
5. Rangaswamy G and A. Mahadevan, 2002. Diseases of crop plants in India, Prentice Hall of India Pvt.Ltd. New Delhi.

Course Outcomes: At the end of the Course, the Student

CO1	Have developed understanding on diversity of microbes
CO2	Have developed basic microbiology skills to study and investigate plant diseases
CO3	Have learnt how to isolate, culture and identify bacteria and fungi from various sample
CO4	Have learnt the significance of molecular biology in microbial identification and characterization.

Course Outcomes and Course Content

Semester	I
Paper Code	**BO 7221**
Paper Title	**Algae and Bryophytes**
Number of teaching hours per week	04
Total number of teaching hours per semester	60
Number of credits	04

Objective of the Paper:
To gain in-depth clarity on ecology, thallus organization, reproduction and life cycles of different groups of algae. To acquire detailed knowledge of different orders of bryophytes and to understand its diversity by type studies. To gain perspective on phylogenetic relationships of algae and bryophytes and appreciate the ecological and economic significance of algae and bryophytes

ALGAE 30 hrs

Unit I: Classification of algae by Fritsch. An introduction to molecular taxonomy of algae. Prokaryotic and Eukaryotic algal cell structure. Diversity of algal plastids, pigments, reserve food material and cell wall composition in various groups of algae. 5

Unit II: An account of environmental factors affecting the distribution of aquatic algae. Freshwater, Marine and Terrestrial Ecology. Algae of unusual habitats– cryophytes, halophytes, thermophilic algae, desert algae. Algae involved in biotic interactions with other organisms. 3

Unit III: Diversity of thallus in Cyanophyceae, Chlorophyceae, Xanthophyceae, Bacillariophyceae, Phaeophyceae and Rhodophyceae. 6

Unit IV: General account of vegetative, asexual and sexual modes of reproduction in algae. Diversity of reproduction in Cyanophyceae, Chlorophyceae, Xanthophyceae, Bacillariophyceae, Phaeophyceae and Rhodophyceae. 6

Unit V: Major life cycle patterns in algae 3

Unit VI: Phylogenetic relationships of different classes of algae and other cryptogams. 3

Unit VII:*Applied Phycology: Methods of cultivation of microalgae and macroalgae. Bioprospecting and Entrepreneurship opportunities for the use of algae in agriculture (with special reference to use as biofertilizers), medicine, in carbon dioxide sequestration and biofuel production.*

Brief account on algal blooms and cyanotoxins ***(self study)*** 4

BRYOPHYTES 30 hrs

Unit I: General characters of Bryophytes – Gametophytic characters; Sporophytic characters; General structure of Bryophyte cell; Vegetative reproduction; sexual reproduction; heteromorphic alternation of generation. 3

Unit II: Classification of bryophytes and criteria of classification.

Characteristic features of the classes- Hepaticopsida, Anthocerotopsida, Bryopsida.

Characteristic features and affinities of the orders- Marchantiales, Sphaerocarpales, Calobryales, Takakiales, Jungermanniales, Anthocerotales, Sphagnales, Andraeales, Funariales, Polytrichales. General account of development of sex organs and sporophyte. 5

Unit III: Diversity in habitat, habit, morphology, anatomy and life cycle of the following genera: *Plagiochasma, Sphaerocarpos, Calobryum, Takakia,Porella, Notothylus, Sphagnum, Andraea, Polytrichum* 14

Unit IV: Origin of Bryophytes- Algal origin and Pteridophytean origin. Inter relationships of bryophytes 2

Unit V: General account of fossil bryophytes 2

Unit VI: *Recent advances in the study of bryophytes (In Brief). Economic and medicinal importance of Bryophytes. (**self study**)* 4

NOTE: 8 hours of self-study assigned

REFERENCES:

1. Bold H.C. and Wynne M.J. 1985. Introduction to the algae: structure and reproduction. Prentice Hall, Englewood Cliffs, N.J.
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17. Trivedi P.C. 2001. Algal biotechnology, Pointer publishers, Jaipur, India.

BLUE PRINT

Code number: **BO 7221**

Title of the paper: **Algae and Bryophytes**

Total marks for which the questions are to be asked (including bonus questions)	Number of hrs	Chapter/ Unit number
ALGAE		
5	3	I
9	5	II
9	6	III
9	6	IV
6	4	V
5	3	VI
6	4	VII
BRYOPHYTES		
5	3	I
8	5	II
22	13	III
3	2	IV
3	2	V
6	4	VI
96	**60**	**TOTAL**
Maximum marks for the paper (Excluding bonus question): **70**		

BO 7P2: Algae and Bryophytes

Total: 44 Hours

Algae

Type study of the following:

- Cyanophyceae : *Microcystis, Oscillatoria, Lyngbya, Rivularia, Gloeotrichia, Nostoc, Stigonema*
- Chlorophyceae : *Scenedesmus, Zygnema, Oedogonium, Desmids, Cladophora, Draparnadiopsis. Coleochaete, Ulva, Codium, Caulerpa.*
- Charophyceae : *Chara*
- Xanthophyceae : *Vaucheria/ Botrydium*
- Bacillariophyceae : Pennate diatoms.
- Phaeophyceae : *Ectocarpus, Dictyota, Padina, Turbinaria, Sargassum*
- Rhodophyceae : *Polysiphonia, Gracilaria*
- Study and identification of common algae from a freshwater body

Bryophytes

Study of morphology and anatomy of the following:

- *Riccia fluitans*
- *Lunularia*
- *Dumortiera*
- *Plagiochasma*
- *Targionia*
- *Asterella*
- *Porella*
- *Pallavicinia*
- *Riccardia*
- *Anthoceros*
- *Sphagnum*
- *Polytrichum*

Submission – Field tour report and identified algal and bryophyte specimens (at least 4)

Course Outcomes: At the end of the Course, the Students

CO1	Have developed sound knowledge in the disciplines of Phycology and Bryology
CO2	Have developed a clear understanding of ecology, structure and life cycles of different groups of algae and bryophytes
CO3	Are able to identify and assign algae to bryophytes upto order level based on thorough study
CO4	To be able to contrast and explain the different useful and harmful roles played by organisms of both groups
CO5	To critique the origin and phylogenetic relationships of algae and bryophytes with other extinct and extant groups
CO6	Are able to collect and preserve samples of algae and bryophytes while identifying some common ones

Course Outcomes and Course Content

Semester	I
Paper Code	**BO 7321**
Paper Title	**Paleobotany, Palynology & Plant Anatomy**
Number of teaching hours per week	04
Total number of teaching hours per semester	60
Number of credits	04

Objective of the Paper:

To study and understand factors responsible for the fossilization process. To learn different techniques of fossil study for knowing fossil plants, their naming and to understand paleoclimate conditions. To apply learnt concepts of paleobotany for the exploration of fossil fuels. To study diverse plant pollen, spores and certain microscopic plankton organisms (collectively termed palynomorphs) in both living and fossil forms for their application in human well being. To study and understand morphological, internal structure of diverse plant groups for the evolution of structure-functions and their application.

PALEOBOTANY 15 hrs

Unit I: *Introduction to paleobotany with particular reference to history, development and scope.*
Fossil localities: *National fossil wood park, Thiruvakkarai, Pondicherry and Yellowstone National Park, USA. (Self study)* 2
Geological phenomena: *Indirectly and directly responsible for Fossilization.* ***(Self study)*** 1

Unit II: Types of fossil plant preservations: Impression, compression, nodule, petrifaction, coal balls, cast, mold and amber. 2
Paleobotanical techniques used in studying plant fossils: Techniques to study microfossils: Maceration of coal and lignite. Techniques to study macrofossils: Impression, compressions, thin ground sectioning and peel technique for petrified specimens. 4

Unit III: Earliest angiosperms. Tertiary flora of India 2

Unit IV: Paleobotanical Nomenclature, provisions made in ICBN for naming of fossil plants. 2

Unit V: Paleobotany in exploration of fossil fuels (coal and oil). 2

PALYNOLOGY 15 hrs

Unit I: *Introduction to Palynology. Basic branches and their scope* ***(self study)*** 2

Unit II: General account of pollen morphology: Polarity, size, shape, symmetry, aperture (NPC classification included). Exine stratification, Ornamentation and *Lux Obscuritas* (L.O) analysis. 4

Unit III: Pollen morphological studies of commonly occurring dicot, *Casuarina, Parthenium, Acacia, Hibiscus, Polygala, Amaranthus* and *Citrus* and monocot - Grass, *Cocos*.
Spore morphology of commonly occurring pteridophytic taxa - *Psilotum, Lycopodium, Selaginella, Equisetum* and *Pteris*. Gymnosperms – *Cycas*, *Ginkgo*, *Pinus*, *Araucaria* and *Ephedra* 1

Unit IV: Palynological techniques used for studying modern pollen and spores: Wodehouse Technique, Erdtman's Acetolysis technique. 1

Unit V: Aspects and prospects of Melittopalynology, pollen analysis of honey, honey pollen flora and its applications. Role of bees in agriculture. 3

Unit VI: General Account of Aerobiology and its applications in human respiratory allergy and immunology. Methods used in atmospheric pollen monitoring, compilation of pollen calendar.
Application of pollen calendar in the detection and treatment of respiratory allergy. 4

PLANT ANATOMY 30 hrs

Unit I: Plant cell wall: Ultra structure and organization.
Types of Vascular bundles - collateral, bicollateral, concentric, medullary bundles, Internal Phloem.
Internodal anatomy – herbaceous dicot and monocot stem ***(self study)***
Nodal Anatomy - Unilacunar, Trilacunar and Multilacunar nodes, Split –lateral condition, Root-stem transition. 5 + 2

Unit II: Leaf Anatomy: Dorsiventral, Isobilateral and Centric leaves, Bundles sheath, foliar sclereids (types and distribution), mature stomatal types and distribution, major and minor venation. 3

Unit III: Primary Xylem: Concepts of Protoxylem - metaxylem;
Diversity in structure of wood: Heart wood, sap wood, growth rings, ring-porous wood: diffuse-porous wood ***(self study)***; Diversity in axial parenchyma distribution, diversity in ray system. 4 + 2

Unit IV: Shoot apical meristem: Structural organization; Tunica – corpus theory, Cytohistological zonation, apices with primary thickening meristem, summit meristem - Acyclic changes in shape and size of shoot apex during different phases of development. Cyclic changes (plastochronic changes).
Root apical meristem-apical cell theory, Histogen theory, Korper-Kappe theory, quiescent centre concept, promeristem concept. 8

Unit V: Vascular Cambium: Structure and activity, uniseriate / Multiseriate nature, cambium zone, types of diversion in the fusiform initials.
Anomalous structure in *Bignonia argentia., Mirabilis jalapa.*, *Aristolochia indica., Beta vulgaris* root. 6

NOTE: 8 hours of self-study assigned

REFERENCES:

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2. Agashe S N. (Ed.) 1997. Aerobiology, Oxford & IBH Publishing Co. Pvt. Ltd. New Delhi.
3. Agashe S N. 1995. Paleobotany: Plant of the past, their evolution, Paleoenvironment and application in exploration of fossil fuels. Oxford & IBH Publishing Co. PVT. LTD.
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16. Abraham F. 1982. Plant anatomy - II edition, Pergaon Press, Oxford.
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18. Cutter D G. 1971. Plant anatomy - Part I, Cell and Tissues Edward Arnold.
19. Cutter D G. 1971. Plant Anatomy - Part II, Cell and Tissues Edward Arnold.
20. Eames and McDaniel. 1947. "Plant Anatomy" II edition, McGraw Hill, NY.
21. Esau K. 1965. Plant Anatomy, II Edition, John Wiley and Sons, NY.
22. James D Mauseth, 1988, Plant Anatomy, The Benzamin / Cummings publish.
23. Katherine Esau, 1979, Anatomy of seed plants - First Wiley Eastern.
24. Fahn A.1989. Plant anatomy. III Edition. Pergomon Press NY, Maxwell Macmillan International Editions.

BLUE PRINT

Code number: **BO 7321**

Title of the paper: **Paleobotany, Palynology and Plant Anatomy**

Total marks for which the questions are to be asked (including bonus questions)	Number of hrs	Chapter/ Unit number
PALEOBOTANY		
4	3	I
8	6	II
4	2	III
4	2	IV
4	2	V
PALYNOLOGY		
4	2	I
6	4	II
2	1	III
2	1	IV
5	3	V
5	4	VI
PLANT ANATOMY		
12	7	I
5	3	II
8	6	III
15	8	IV
8	6	V
96	**60**	**TOTAL**
Maximum marks for the paper (Excluding bonus question): **70**		

BO 7P3: Paleobotany, Palynology and Plant Anatomy

Total: 44 Hours

Paleobotany

1. Study of non-fossiliferous and fossiliferous rocks.
2. Types of fossil plant preservations: Impression, Compression, Cast, Nodule, Silicified petrifaction, Calcified petrifaction (coal ball).

Palynology

3. Demonstration of acetolysis technique and Preparation of permanent pollen reference slides using acetolysis technique.
4. Study of pollen morphology of common angiosperm taxa from permanent slides.
5. Mellittopalynology – Unifloral honey and Multifloral honey

Plant Anatomy

6. Study of epidermal appendages
7. Stomatal types
8. Tracheary cells
9. Root Anatomy
10. Microtomy
11. Stem anatomy – Wood Anatomy - Dendrochronology
12. Leaf anatomy
13. Double staining technique.
14. Maceration technique

REFERENCES:

1. Henry N Andrews. 1967. Studies in Paleobotany. John Wiley & Sons.
2. Agashe S N. 2006. Palynology and its application, Oxford & IBH Publishing Co. Pvt. Ltd. New Delhi.
3. Erdtman G. 1957 "Pollen & spore Morphology / plant taxonomy Vol. I-V. Hafner Pub. Co. New York.
4. Ashok M Bendre & Ashok Kumar. A Text Book of Practical Botany II. Rastogi Publications.

Course Outcomes: At the end of the Course, the Student

CO1	Have developed a good knowledge of the history, development and scope of the discipline of Paleobotany, Palynology and Plant Anatomy and the contributions made by prominent scientists.
CO2	Have developed a very good understanding of factors involved in the fossilization process, the various techniques of studying different forms of fossils, and the paleoclimatic conditions favoring the evolution of higher land plants and the usefulness of paleobotany in exploration of fossil fuels and other useful products.
CO2	Are able to perform basic experiments to understand the morphology of pollen grains and their significance in the plant development, and various other sub-disciplines of palynology and their applications for the welfare of mankind.
CO3	Are able to apply the concepts of Plant Anatomy to better understand the structural organization and functions of various tissue systems of plant body.
CO4	Critique the contribution of past plant life forms in the development of advanced plants through the course of evolution.
CO5	Can explore the structure-function relationships of various plant forms in the advancement of the discipline by performing experimental studies.

Course Outcomes and Course Content

Semester	I
Paper Code	**BO 7421**
Paper Title	**Biostatistics and Bioinformatics**
Number of teaching hours per week	04
Total number of teaching hours per semester	60
Number of credits	04

Objective of the Paper:

To understand theoretical and practical significance of statistics analyses in biological studies
To learn basic operations and tools in bioinformatics
To be able to carry out bioinformatics and biostatistics based research work

Unit I

Introduction to Biostatistics — 13 hrs

History of Biostatistics — **1 hr**

- Contributions of Karl Pearson
- Contributions of Roland Fischer
- Contributions of Francis Galton
- Contributions of Prasanta Mahalanobis
- Applications of Biostatistics — **1 hr**

Concepts of Biostatistics — **2 hrs**

- Descriptive & Inferential Statistics
- Population; Sample; Data
- Variables & Replications

Sampling techniques — **2 hrs**

- Methods & Types of Sampling
- Random & Non-Random Sampling
- Sampling & Non-Sampling Errors

Study design — **2 hrs**

- Concepts of Control
- Replicates & Randomization
- CRD & RCBD

Concepts & Problems — **5 hrs**

- Measures of central tendency
- Mean, Median & Mode
- *(Problems and solutions related to mean, median and mode only)*

Unit II

Data Analysis & Representation — 17 hrs

Graphical Representations — **6 hrs**

Line diagrams; Bar diagrams; Histograms; Pie diagrams
Frequency Polygons; Frequency Curves (Ogives)
Stem & Leaf Chart ; Scatter Plot

Measures of dispersion — **3 hrs**

Variance & Standard Deviation
Coefficient of Variation
Skewness & Kurtosis

Correlation and Regression — **3 hrs**

Analysis of Correlation and Regression
Coefficient of Correlation & Regression

Probability — **2 hrs**

Rules of Probability
Normal**,** Poisson & Binomial distributions

Hypothesis Testing — **3 hrs**

Tests of significance
Degrees of Freedom
T-Test; Chi-square test
ANOVA

Unit III

Introduction to Bioinformatics — 13 hrs

History of Bioinformatics — **7 hrs**

Introduction to Computational Biology
Applications & History of Bioinformatics
Neworking Standards & Types
World Wide Web
Java, Bio-Perl & Python programming languages

Databases — **6 hrs**

Mendeley Reference Manger
Database Structure, Classification & Growth
Types of Biological Databases
NCBI; EMBL; ExPASy; DrugBank; Array Express
Genome Online Database
Human Genome Project & Its Significance

Unit IV

Tools In Bioinformatics — 17 hrs

Genomics & Proteomics — **4 hrs**

Genomics: Introduction to Gene Sequencing
Types of Gene Sequencing Methods
Proteomics: Introduction to Experimental Methods & Protein Structure
Protein-Ligand Interactions

Sequence Analysis **6 hrs**

Sequence Alignment
Pairwise & Multiple Sequence Alignments (Clustal Omega)
Needleman &Wuncsh; Smith & Waterman algorithms
BLAST Analysis
Phylogenetic analysis
Types of Phylogenetic Tree
Tools of Phylogenetic Tree Analysis (MEGA-X)

Structural Analysis **7 hrs**

PyMol Protein Structure Visualization
Tools for Protein Structure Analysis (JPred)
ProFunc- Protein Function Prediction
Homology Modelling; Ramachandran Plot
Tools for Protein-Ligand Docking (AutoDock Vina)
Computer Aided Drug Design

REFERENCES:

1. Andreas D. Baxevanis and B. F. Francis Ouellette Bioinformatics (2001). A Practical Guide to the Analysis of Genes and Proteins, Second Edition 2nd Edition; Willey&Sons.
2. Bailey, N.T.J. 1995. Statistical methods of Biology 3rd edition, Cambridge University Press
3. Bioinformatics and Biostatistics James M. Bower and Hamid Bolouri (2011).Computational Modeling of Genetic and Biochemical Networks. MIT Pubs
4. Daniel, W. W. (2007). Biostatistics- A Foundation for Analysis in the Health Sciences, Wiley.
5. Daniel, W.W., 1978. Biostatistics : A foundation for analysis in health sciences 2nd edition. John Wiley, NY.
6. Dutta, N. K. (2004). Fundamentals of Biostatistics, Kanishka Publishers.
7. Eynon B.P. and T.W. Anderson, Minitab guide to Statistics.
8. Gurumani N. (2005) .An Introduction to Biostatistics, MJP Publishers.
9. Jayarama Reddy (2011)Fundamentals of Bioinformatics.SS Education Series: 1st edition 2011
10. Jayarama Reddy (2017) Bioinformatics and Biostatistics, Publishers- Geetha Book House, Bengaluru, ISBN:(9789352679515)
11. Jayarama Reddy (2017) Bioinformatics and Biostatistics, Publishers- Geetha Book House, Bengaluru.
12. Khan, I.A. and Khanum, 1994.Fundamentals of Biostatistics, Ukaaz Publications Hyderabad.
13. Mark Borodovsky and Svetlana Ekisheva (2006). Problems and Solutions in Biological Sequence Analysis Cambridge University Press; 1st edition
14. Pagano, M. & Gauvreau, K. (2007). Principles of Biostatistics.
15. Pavel A. Pevzner, Phillip Compeau (2015). Bioinformatics Algorithms. Active Learning Publishers, 2015
16. Rao, K. V. (2007). Biostatistics - A Manual of Statistical Methods for use in Health Nutrition and Anthropology.
17. Remington, R.D. and Schork, M.A. 1970. Statistics with applications to the Biological and health sciences, Prentice Hall Inc. NY.

18. Rohatgi, V.K.&Saleh, A.K.Md. (2001). An Introduction to Probability and Statistics, John Wiley & Sons.
19. Sundaram, K.R.(2010) Medical Statistics-Principles& Methods, BI Publications, New Delhi 14
20. SundarRao, P.S.S. and Richard, J. 1996. An introduction to Biostatistics, 3rd edition Prentice Hall India.
21. Teresa Attwood, David Parry-Smith (1999) Introduction to Bioinformatics. 1st edition; Prentice Hall
22. Zhumur Ghosh and Bibekanand Mallick (2008). Bioinformatics: Principles and Applications. Oxford University Press-New Delhi.

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Code number: **BO 7421**
Title of the paper: **Biostatistics and Bioinformatics**

Total marks for which the questions are to be asked (including bonus questions)	Number of hours	Unit Number
21	13	I
27	17	II
21	13	III
27	17	IV
96	**60**	**TOTAL**
Maximum marks for the paper (Excluding bonus question): **70**		

PRACTICALS - BO 7P4: Biostatistics & Bioinformatics

Total: 44 hours

1. Mendeley Reference manager
2. Data Analysis in MS Office Excel (Basic Statistics)
3. Data Representation in MS Office Excel (Graph Plot)
4. Data Retrieval from Databases (PubMed, NCBI, Expasy PDB & TAIR)
5. Sequence Alignment: BLAST & Clustal Omega Analysis ,
6. Homology Modelling of Protein 3D Structure
7. Phylogenetic Tree Construction (MEGA-X)
8. Secondary structure prediction (ProFunc)
9. Molecular visualization tools (PyMol)
10. Protein-Ligand Docking Analysis (AutoDock Vina)
11. Basics operations of R-programming & SAS

Activity: Project Based Learning of the Tools & Submission of Computational Models to PMDB.

REFERENCES:

1. Bailey, N.T.J. 1995. Statistical methods of Biology 3rd edition, Cambridge University Press
2. Daniel, W. W. (2007). Biostatistics - A Foundation for Analysis in the Health Sciences, Wiley.
3. Daniel, W.W., 1978. Biostatistics: A foundation for analysis in health sciences 2nd edition. John Wiley, NY.
4. Mark Borodovsky and Svetlana Ekisheva (2006). Problems and Solutions in Biological Sequence Analysis Cambridge University Press; 1st edition
5. Pavel A. Pevzner, Phillip Compeau (2015). Bioinformatics Algorithms. Active Learning Publishers, 2015
6. Teresa Attwood, David Parry-Smith (1999). Introduction to Bioinformatics. 1st edition; Prentice Hall
7. Zhumur Ghosh and Bibekanand Mallick (2008). *Bioinformatics: Principles and Applications.* Oxford University Press-New Delhi.

Course Outcomes: At the end of the Course, the Students Would

CO1	Have developed in-depth knowledge of statistical and computational analysis in relation to Biological applications
CO2	Be able to analyze and understand statistical analysis in biological research
CO3	Be able to carry out structural and sequence bioinformatics work in real-time research projects.
CO4	Be able to access and retrieve information from public databases and incorporate in further research applications
CO5	Be able to provide added value to any biological studies with statistical and computational (multi-disciplinary) components

MAPPING

Mapping OF Mission statements with Program Educational Objectives

Mission Statements	PEO1	PEO2	PEO3	PEO4	PEO5
M1					
M2					
M3					
M4					

(**Tick mark or level of correlation:** 3-High, 2-Medium, 1-Low can be used)

Mapping of PEOs with PSOs

PEOs/POs	PSO1	PSO2	PSO3	PSO4	PSO5
PEO1					
PEO2					
PEO3					
PEO4					
PEO5					

(**Tick mark or level of correlation:** 3-High, 2-Medium, 1-Low can be used)

Mapping of Course Outcomes to Program Outcomes

PEOs/POs	PSO1	PSO2	PSO3	PSO4	PSO5
CO1					
CO2					
CO3					
CO4					
CO5					
CO6					

(Tick mark or level of correlation: 3-High, 2-Medium, 1-Low can be used)

NOTE : Mapping of Course Outcomes to Program Learning Outcomes is written after every course

SECOND SEMESTER – M.Sc. BOTANY

CORE COURSES (CC)	
Course Title	Code Number
Pteridophytes and Gymnosperms	**BO 8121**
Plant Morphogenesis and Embryology	**BO 8221**
Plant Physiology and Metabolism	**BO 8321**
Tools and Techniques in Plant Sciences	**BO 8421**

DISCIPLINE SPECIFIC ELECTIVE COURSES (DSE)	
Course Title	Code Number
Advanced Physiology	**BODE 9321**
Plant Tissue Culture	**BODE 9421**
Microbiology	**BODE 0418**
Systematics of Angiosperms	**BODE 0518**

GENERIC ELECTIVE COURSES (GSE)/ Can include open Electives offered	
Course Title	Code Number
Horticulture	**BOOE 9518**

SKILL ENHANCEMENT COURSE (SEC) – Any practical oriented and software based courses offered by departments to be listed below	
Course Title	Code Number
Plant Tissue Culture	BO 9P4
Biostatistics & Bioinformatics	BO 7421
Systematics of Angiosperms	BO 0518

VALUE ADDED COURSES (VAC) **Certificate courses that add value to the core papers can be listed.**	
Course Title	Code Number
Bioinformatics	
SAS programming	
Clinical Research and Management	
Microbiology	BO 0418
Systematics of Angiosperms	BO 0518

Online courses offered or recommended by the department to be listed	
Course Title	Code Number

SECOND SEMESTER
Course Outcomes and Course Content

Semester	II
Paper Code	**BO 8121**
Paper Title	**Pteridophytes and Gymnosperms**
Number of teaching hours per week	04
Total number of teaching hours per semester	60
Number of credits	04

Objective of the Paper:
To study the structure, diversity and economic aspects of Pteridophytes and Gymnosperms. To impart knowledge on their distribution, ecological significance and recent advances in Pteridophytes and Gymnosperms research.

PTERIDOPHYTES **30 hrs**

Unit I: *General characters of pteridophytes and classification (according to Reimer, David W. Beirhost, Gifford and Foster) (self study)* 2

Unit II: Diversity in morphology and reproduction of the following orders : Psilotales, Lycopodiales, Isoetales, Equisetales, Ophioglossales, Marattiales, Osmundales, Filicales, Marsileales, Salviniales, Psilophytales, Lepidodendrales and Calamitales 16

Unit III: Fossil Pteridophytes – Systemic position, Structure of sporophytes and gametophytes, Reproduction of the following:
Psilophytales: *Horneophyton*, comparision with *Rhynia, Asteroxylon*,
Lepidodendrales: *Lepidodendron, Lepidostrobus, Lepidocarpon* and
Calamitales: *Calamites* and *Spenophyllum* 6

Unit IV: Heterospory and seed habit. Stelar evolution, Phylogenetic relationship. 4

Unit V: *Recent advances on Pteridophytes. Economic importance of Pteridophytes. (Self study)* 2

GYMNOSPERMS 30 hrs

Unit I: General characters of Gymnosperms. Classification (Pant 1957, Takhtajan 1966, Sporne 1974, Bhatnagar and Moitra 1996), Gymnosperms of India: distribution and conservation status. 4

Unit II: Diversity in morphology, anatomy and reproduction of the following orders:
Cycadales, Ginkgoales, Coniferales, Taxales, Gnetales. 11

Unit III: Fossil Gymnosperms: Systemic position, Structure of sporophytes and gametophytes, Reproduction of the following Pteridospermales (*Glossopteris, Medullosa*), Cycadeoideales (*Cycadeoidea, Williamsonia*), Pentoxylales (*Pentoxylon*) and Cordaitales (*Cordaites*) 6

Unit IV: Origin and evolutionary significance of Gymnosperms. 2
Affinities of Gymnosperms with pteridophytes and angiosperms. (Self study) 1
Xylotomy of Gymnosperms. Comparative anatomy and developmental morphology of gymnosperms, Polyembryony in Gymnosperms 3
Economic Importance of Gymnosperms. (Self study) 1

Unit V: *Recent advances in the study of Gymnosperms (Self study).* 2

NOTE: 8 hours of self-study assigned

REFERENCES:

Pteridophytes

1. Eames, A.J. 1936. Morphology of vascular plants (lower groups), McGraw - Hill, New York.
2. McClean, R.C. and Ivimey - Cook, W.R. 1964. Text book of theoretical botany. Vol I. Longmans, Green and Co., Ltd., London.
3. Parihar, N.S. 1977. The morphology of pteridophytes. Central Book Depot. Allahabad.
4. Smith, G.M. 1955. Cryptogamic botany. Vol. II. McGraw - Hill, New York.
5. Sporne, K.R. 1966. The morphology of Pteridophytes. The structure of ferns and allied plants. Hutchinson University Library, London.
6. Vashishta, P.C. 2014. Pteridophyta.S Chand and Company, Pvt. Ltd. New Delhi.
7. SharmaO.P.1990.Text book of Pteridophyta. Macmillan India Ltd.
8. Sundararajan, S. 1994. Introduction to Pteridophyta. New Age International Publishers.
9. Blatter, E. 1992.The ferns of Bombay. D.B. Taraporevala sons & co. Fort.
10. Pandey, B.P.2007.College Botany vol. II., S Chand and Company, Pvt. Ltd. New Delhi.
11. Suresh Kumar2014.Text book of Pteridophyta. Sonali publications, New Delhi.

12. BeddomeB.H.1866. The ferns of British India, vol.I & II. Gantz Brothers.
13. Benniamin, A., Irudayaraj, V. and Manickam, V.S. (2008). How to identify rare and endangered ferns and fern allies. Ethnobotanical Leaflets, 12: 108 - 117.

Gymnosperms

14. Agashe, S.N. 1995. Paleobotany. Plants of the past, their evolution, paleoenvironment and application in exploration of fossil fuels. Oxford & I.B.H. New Delhi.
15. Andrews, H.N. 1961. Studies in Paleobotany. John Wiley, New York.
16. Bhatnagar, S.P. and Moitra, A. 1997. Gymnosperms. New Age International Ltd., New Delhi.
17. McClean, R.C. and Ivimey - Cook, W.R. 1964. Text book of theoretical Botany. Vol I. Longmas, Green and Co., Ltd., London.
18. Sporne, K.R. 2015. The morphology of gymnosperms. The structure and evolution of primitive seed plants. Hutchison University Library, London.
19. Biswas C and Johari B.M 2004. The Gymnosperms Narosa Publishing House, New Delhi.
20. Sharma OP. 2016. Gymnosperms. Pragati Prakashan, Meerut.
21. Stewart WN and Rothwell GW. 1993. Paleobotany and the Evolution of Plants. Cambridge University Press, USA.
22. Sambamurthy, A.V.S.S. 2005. A Textbook of Bryophytes, Pteridophytes, Gymnosperms and paleobotany. I.K. International Publishing House. New Delhi.
23. Govil C.M. 2011. Gymnosperm. Krishna Prakashan Media.
24. Chamberlain CJ. 2009. Gymnosperms structure and evolution. University of Chicago Press, USA.

BLUE PRINT

Code number: **BO 8121**

Title of the paper: **Pteridophytes and Gymnosperms**

Total marks for which the questions are to be asked (including bonus questions)	Number of hrs	Chapter/ Unit number
Pteridophytes		
4	2	I
24	16	II
14	6	III
4	4	IV
2	2	V
Gymnosperms		
4	4	I
20	11	II
10	6	III
12	7	IV
2	2	V
96	**60**	**TOTAL**
Maximum marks for the paper (Excluding bonus question): **70**		

<u>BO 8P1:</u> Pteridophytes and Gymnosperms

Total: 44 Hours

Pteridophytes

1. Study of morphology and anatomy of vegetative and reproductive structures of the following: *Isoetes, Ophioglossum, Angiopteris, Marattia, Osmunda, Gleichenia, Hymenophyllum, Adiantum, Pteris, Cyathea, Salivinia and Azolla.*
2. Fossil pteriodophytes studied in theory (specimens and slides).

Gymnosperms

3. A study of the morphology and anatomy of vegetative and reproductive structures of the following: *Zamia, Ginkgo, Cedrus, Araucaria, Podocarpus, Cupressus, Ephedra and Welwitchia* (Spotters/slides/ specimens)

4. Fossil gymnosperms - *Medullosa anglica, Cycadeoidea, Cordaites, Cardiocarpus spinatus, Glossopteris, Vertebraria, Pentoxylon,Cornoconites.*

REFERENCES:

Pteridophytes

1. Eames, A.J. 1936. Morphology of vascular plants (lower groups), McGraw - Hill, New York.
2. Parihar, N.S. 1977. The morphology of pteridophytes. Central Book Depot. Allahabad.
3. Sporne, K.R. 1966. The morphology of Pteridophytes. The structure of ferns and allied plants. Hutchinson University Library, London.
4. Vashishta, P.C. 2014. Pteridophyta.S Chand and Company,Pvt.Ltd.New Delhi.
5. Sharma, O.P.1990.Text book of Pteridophyta.Macmillan India Ltd.
6. Sundararajan, S. 1994. Introduction to Pteridophyta. New Age International Publishers.
7. Pandey, B.P.2007.College Botany vol. II., S Chand and Company, Pvt. Ltd. New Delhi.
8. Benniamin, A., Irudayaraj, V. and Manickam, V.S. (2008). How to identify rare and endangered ferns and fern allies. Ethnobotanical Leaflets, 12: 108 - 117.

Gymnosperms

1. Agashe, S.N. 1995. Paleobotany. Plants of the past, their evolution, paleoenvironment and application in exploration of fossil fuels. Oxford & I.B.H. New Delhi.
2. Andrews, H.N. 1961. Studies in Paleobotany. John Wiley, New York.
3. Bhatnagar, S.P. and Moitra, A. 1997. Gymnosperms. New Age International Ltd., New Delhi.
4. Sporne, K.R. 2015. The morphology of gymnosperms. The structure and evolution of primitive seed plants. Hutchison University Library, London.
5. Biswas C and Johari B.M 2004. The Gymnosperms. Narosa Publishing House, New Delhi.
6. Sharma OP. 2016. Gymnosperms. Pragati Prakashan, Meerut.
7. Stewart WN and Rothwell GW. 1993. Paleobotany and the Evolution of Plants. Cambridge University Press, USA.
8. Sambamurthy, A.V.S.S. 2005. A Textbook of Bryophytes, Pteridophytes, Gymnosperms and paleobotany. I.K. International Publishing House. New Delhi.

Course Outcomes: At the end of the Course, the Student will be able to:

CO1	Demonstrate an understanding of Pteridophytes and Gymnosperms
CO2	Develop critical understanding on morphology, anatomy and reproduction of Pteridophytes and Gymnosperms
CO2	Demonstrate proficiency in the experimental techniques and methods of appropriate analysis of Pteridophytes and Gymnosperms

Course Outcomes and Course Content

Semester	II
Paper Code	**BO 8221**
Paper Title	**Plant Morphogenesis and Embryology**
Number of teaching hours per week	04
Total number of teaching hours per semester	60
Number of credits	04

Objective of the Paper:
To study and understand inception of form and structure in the ontogeny of plant. To critique the theories of nature of organs, concept of polarity, the processes of differentiation, and acquire knowledge on morphogenesis and organogenesis in plants. To study the genetic aspects of flowering. To familiarize with the process of fertilization and related processes in higher plants.

PLANT MORPHOGENESIS **25 hrs**

Unit I: Aim, scope and historical account of Plant Morphogenesis 1

Morphogenetic Studies: Morphogenesis *in vivo* (Field concepts and Meristemoid); Experimental studies on shoot apex, root apex and differentiated organs. 5

Unit II: Organogenesis in Plants:

Formation of leaves – Cellular and Genetic basis; *Types of phyllotaxy* ***(Self study***);

Transformation of vegetative apex into reproductive apex.

Nature of organs: Theories on nature of shoot (Phytonic and axial theories) and flower (Monaxial, pluriaxial, suigeneris and acarpy: appendicular and axial theories of inferior ovaries). 9

Unit III: Polarity: *Contemporary understanding at different levels of organization and in different organisms -* ***(self study****)* 3

Differentiation – patterns of differentiation, vascular differentiation, role of growth hormones in vascular differentiation. 3

Unit IV: Flower: Serial evocation of genes and floral development; genetic analysis of floral development ABCDE model *(Arabidopsis),* flower regulatory genes (MADS box genes). 4

EMBRYOLOGY **35 hrs**

Unit V: Microsporangium: Development and structure; differentiation of anther wall and their role.

Microsporogenesis: General account, ultrastructure and physiology; role of callose.

Male gametophyte: Development and Structure; differential behaviour of generative and vegetative cells; formation of male gametes, sperm dimorphism, male germ unit.

Development of male gametophyte – molecular and genetic basis using *Arabidopsis* as a model 7

Pollen abnormalities - pollen sporophytes, Nemec phenomenon, pollen development in Cyperaceae ***(Self study*****)** 2

Unit VI: Ovule: A general account of ontogeny, types and diversity in structure.

Megasporogenesis: General account, Ultra structure and physiology.

Female gametophyte, Diversity in organization; ultra structure of female gametophyte, embryosac haustoria. Study of female gametophyte development in *Oryza sativa* – genetic basis 9

Unit VII: Fertilization: Structure of stigma and style, role of stigmatic exudates; pollen germination *in vivo* ; pollen tube entry into the stigma; pollen tube growth ; entry of pollen tube into female gametophyte ; double fertilization; hetero-fertilization and single fertilization., *in vitro* fertilization, Polyspermy. 5

Unit VIII: Sexual incompatibility: Self incompatibility, genetic basis, barriers to fertilization, physiology and biochemistry of incompatibility, stigmatic surface and stylar inhibition, biological significance. 4

Unit IX: Endosperm: Types, Development and reserve food materials, embryo-endosperm relationship, Endosperm haustoria.

Embryo: *Classification based on early development of embryo; Structure and Composition of embryo* ***(Self study)***

Early embryogenesis in *Capsella* (Dicot) and *Najas* (Monocot). Chimeral embryos. Polyembryony, apomixis in brief. 8

NOTE: 8 hours of self-study assigned

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Code number: **BO 8218**
Title of the paper: **Plant Morphogenesis and Embryology**

Total marks for which the questions are to be asked (including bonus questions)	Number of hours	Unit Number
10	6	I
13	9	II
10	6	III
6	4	IV
14	9	V
14	9	VI
8	5	VII
6	4	VIII
15	9	IX
96	**60**	**TOTAL**
Maximum marks for the paper (Excluding bonus question): **70**		

BO 7P3: Plant Morphogenesis and Embryology

Total: 44 Hours

Plant Morphogenesis:

- Study of shoot apices by dissections using aquatic plants *(Ceratophyllum & Hydrilla).*
- Study of cytohistochemical zonation in the shoot apical meristem in sectioned and double stained micropreparation of a suitable plant. Study of development of bisected shoot apices.
- Study of L.S. of roots from permanent micropreparation to understand the organization of root apical meristem and its derivatives
- Study of alternate and distichous, alternate and superposed, opposite and superposed, opposite and decussate leaf arrangement.
- Diagrammatic representation on theories of shoot and flower, Regeneration experiment with stem cuttings to show polarity.

Embryology:

- Study of the following stages from permanent micro-preparation: Anther wall, Microsporogenesis. Pollen mitosis; pollen in cyperaceae; Isolation of male gametes.
- Pollen germination in *Balsam, Vinca, Datura, Delonix, Peltophorum* and the effect of sucrose, Boron and Calcium on germination.
- Types of placentation, Types of ovules and ovular parts.
- Megasporogenesis and female gametophyte *(Polygonum type)*
- Study of endosperm: types, endosperm haustoria
- Embryo - Mature dicot and monocot embryos. Mounting of globular, cordate and torpedo shaped embryos from suitable seeds.

REFERENCES:

1. Bhojwani S.S. Bhatnagar S.P. and P.K. Dantu, 2015. The embryology of angiosperms, 6th Ed., Vikas Pub. New Delhi.
2. Davis G.L. 1966. Systematic embryology of Angiosperms, John Wiley & Sons, Inc. New York.
3. Easu K. 1977. Anatomy of seed plants 2nd ed. Wiley Eastern New Delhi.
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Course Outcomes: At the end of the Course, the Student

CO1	The student will attain subject knowledge in plant morphogenesis and embryology by understanding the principles of morphology and allied fields with respect to the organized growth of plant structure which involves both organogenesis and histogenesis.
CO2	The student will assess the structural organization of flower and the process of pollination and fertilization.
CO3	The students will gain ability to apply the acquired knowledge and skills in the field of plant morphology, morphogenesis and embryology.
CO4	At the end of this unit , students would understand the process of differentiation of anther and the role of various layers in pollen development
CO5	Students would understand the process of megasporogenesis , contribution of different layers to the development of the embryo and variation seen in embryo sacs

Course Outcomes and Course Content

Semester	II
Paper Code	**BO 8321**
Paper Title	**Plant Physiology and Metabolism**
Number of teaching hours per week	04
Total number of teaching hours per semester	60
Number of credits	04

Objective of the Paper:

To gain conceptual clarity of various physiological processes in plants. To study and understand the interconnectedness of the metabolic pathways, its regulation and energetics in plants.

Unit I: Energy flow: General concepts, thermodynamic parameters and their interrelations, Laws of thermodynamics, Spontaneous, non-spontaneous and coupled reactions, redox reactions, structure and functions of ATP. 3

Unit II: Introduction to biomolecules

Carbohydrates: Classification, structure and significance of monosaccharides, oligosaccharides and polysaccharides.

Proteins: Classification, structure and significance of amino acids. Structural organization of proteins (primary, secondary, tertiary and quaternary structures, domains, motifs and folds).

Lipids: Classification, structure and significances of lipids. Synthesis of triglycerides, and some important plant phospholipids and glycolipids. 6

Unit III: Fundamentals of enzymology: *Features of enzymes, types of enzymes based on structure. Nomenclature and classification of enzymes* ***(self study)***.

Models of enzyme-substrate binding – Lock and key model, Induced fit model and Conformational selection model. Enzyme kinetics: Co-ordination diagram of exothermic and endothermic reactions, Factors affecting enzyme kinetics, Michelis– Menten equation with derivation and LB plot. Enzyme inhibition – Irreversible, Reversible – Competitive, Non-competitive, mixed and uncompetitive inhibition. A brief concept of allosteric enzymes. 7 + 2

Unit IV: Membrane transport and translocation of water and solutes:

Concept of water potential*, diffusion, osmosis and imbibition (****self study****).*

Mechanism of absorption of water and minerals (active and passive) and ascent of sap – Cohesion-Tension theory. Brief outline of aquaporins.

Loss of water – Guttation, Transpiration – types, theories of stomatal movement (turgor pressure theory,

starch hydrolysis theory, K^+ transport theory) and *factors affecting rate of transpiration (**self study)**.*

Translocation of solutes (passive and active). 7 + 2

Unit V: Photosynthesis: *Ultrastructure of chloroplast, photosynthetic pigments. **(self study).*** Interaction of light with photosynthetic pigments (photochemistry). Ultrastructure of components of electron transport. Mechanism of electron transport (cyclic and non-cyclic). Mechanism of photophosphorylation (chemiosmotic hypothesis and binding change mechanism). Calvin cycle, C4 cycle, CAM pathway - their enzymatic regulation and significance. Synthesis and degradation of Starch and Sucrose*, Gluconeogenesis (**Self study)**.*

Photorespiration and its significance. 12 + 3

Unit VI: Respiration: General aspects, Glycolysis, TCA cycle, Ultrastructure of components of electron transport chain and oxidative phosphorylation (mechanism of ATP synthesis covered in Unit V), Pentose phosphate pathway and its enzymatic regulation, Alternative respiration. Glyoxylate pathway 7

Unit VII: Nitrogen metabolism: Biological Nitrogen fixation, Symbiotic nitrogen fixation in legumes - nodule formation and nod factors, Nif genes, Nitrogenase – its properties and mechanism of action. 4

Unit VIII: Plant growth hormones: Biosynthesis and Physiological effects of Auxins, Cytokinins, Gibberellins, Ethylene, Abscisic Acid.

An overview of brassinosteroids, *jasmonates & polyamines **(self study)*** 6 + 1

NOTE: 8 hours of self-study assigned

REFERENCES:

1. L. Taiz, E. Zeiger, I.M. Moller and A. Murphy, 2015, Plant Physiology 6th Ed., Sinauer Associates, Inc, USA.
2. W.G. Hopkins and N.P.A. Huner, 2009, Introduction of plant physiology, 4th Edition, John Wiley and Sons, Inc.
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7. David L. Nelson and Michael M. Cox, 2008, Lehninger – Principles of Biochemistry, Macmillan Higher Education, England

BLUE PRINT

Code number: **BO 8321**

Title of the paper: **Plant Physiology and Metabolism**

Total marks for which the questions are to be asked (including bonus questions)	Number of hrs	Chapter/ Unit number
6	3	I
10	6	II
14	9	III
14	9	IV
24	15	V
11	7	VI
6	4	VII
11	7	VII
96	**60**	**TOTAL**
Maximum marks for the paper (Excluding bonus question): **70**		

<u>BO 8P3:</u> Plant Physiology and Metabolism

Total: 44 Hours

1. Preparation of solutions and reagents
2. Characterization of stomatal movements under different stresses with T testing
3. Effect of temperature, different salts and solvents on the membrane permeability in plant tissues
4. Separation of chlorophyll pigments by solvent wash method; determination of absorption spectra of individual pigments and estimation of total chlorophyll
5. Qualitative biochemical tests of carbohydrates, proteins and lipids.
6. Estimation of Leghaemoglobin in root nodules
7. Effect of temperature and pH on enzyme kinetics(any enzyme from a culture of microorganism)
8. Effect of concentration of substrate and enzyme on enzyme kinetics.
9. Effect of gibberellic acid on amylase activity of germinating seeds.
10. Estimation of lipase activity in germinating seeds.

Course Outcomes: At the end of the Course, the Students

CO1	Have developed good knowledge of the physiology and metabolic processes in plants.
CO2	Have developed a clear understanding of bioenergetics, anabolic and catabolic enzyme catalyzed reactions in plants.
CO3	Are able to perform experiments to understand the functioning of plants through *in vivo* and *in vitro* methods.
CO4	Are able to apply the concepts of plant physiology in the fields of Plant Tissue Culture, Agriculture and Horticulture.
CO5	Are able to design their own experiments to study plant physiological processes under different experimental conditions.

Course Outcomes and Course Content

Semester	II
Paper Code	**BO 8421**
Paper Title	**Tools and Techniques in Plant Sciences**
Number of teaching hours per week	04
Total number of teaching hours per semester	60
Number of credits	04

Objective of the Paper:
To understand the principles, instrumentation and applications of Microscopy, microtomy, centrifugation, chromatography and electrophoresis. To be able to write and communicate a research paper.

Unit I 7 hrs
Microscopy, History and Introduction: History of Microscopy. Properties of light in relation to microscopy - Wavelength, resolution, reflection, transmission, absorption, refraction, diffraction; Relationship between resolving power and numerical aperture. Aberrations in Microscopy (spherical, chromatic and field curvature). Lenses used in compound microscope – Abbe's condenser system, objective lenses, ocular lenses and mirror.

Unit II **7** + 1 hrs
Types of Microscopes: Principle, construction and uses of bright field microscopy, dark field microscopy, stereomicroscopy, phase contrast microscopy, Nomarski (DIC) microscopy, inverted microscopy, polarization microscopy, confocal microscopy, fluorescent microscopy, electron microscopy (TEM, SEM), atomic force microscope, Camera lucida, *photomicrography (self-study)* and image analysis.

Unit III 5 hrs
Microtomy: Microtomy and ultra microtomy techniques, fixatives, clearing agents, dehydrants, stains, staining schedules, freeze fracturing, freeze etching; cryopreservation.

Unit IV 11 + 1 hrs
Centrifugation: Principle and types of centrifuges and rotors; techniques of centrifugation, *brief account of cell fractionation (self-study).*
Spectroscopy: UV-Vis, FTIR, NMR (Proton, Carbon, DEPT, 2D), AAS, XRD.
Radiobiology: radioisotope techniques (EMSA, GM counter, scintillation and autoradiography).

Unit V 12 + 1 hrs
Separation and purification techniques: Electrophoresis (agarose and PAGE), isoelectric focussing.

Chromatography, types and applications: *History and introduction (self-study).* Paper chromatography (ascending, descending, 2D), TLC, HPTLC, Column chromatography, Gel filtration, affinity, ion exchange, Gas chromatography, HPLC and hydrophobic interaction chromatography.

Unit VI 10 + 5 hrs

Biophysics: Intra and intermolecular interactions: atomic structure, chemical bonding (ionic, covalent, hydrogen and coordinate bonds). Van der Walls interactions and London forces of dispersion

Colloids: *Properties, dispersion system, classification of colloids (sol, gel, suspension and emulsion). Tyndall effect and Brownian movement. Applications of colloids. (self-study).*

Luminescence: *Principles and applications of phosphorescence, fluorescence and bioluminescence. (self-study).*

Biomechanics: Principles and applications of biomechanics, nano-biotechnology and protein engineering.

Review of research papers related to the application of the above techniques.

NOTE: 8 hours of self-study assigned

REFERENCES:

1. R. Cotterill (2002). Biophysics – An Introduction, John Wiley & Sons.
2. Pranav Kumar (2017). Fundamentals and Techniques of Biophysics and Molecular Biology, Second Edition, Pathfinder Publications, New Delhi.
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23. Homes, B. D. Gel electrophoresis of proteins -a practical approach.
24. Sabari Ghosal & A. K. Srivastava (2009), Fundamentals of Bioanalytical techniques and instrumentation, PHI Learning Pvt. Ltd., New Delhi.
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26. K.L. Ghatak (2011). Techniques and Methods in Biology, PHI Learning Pvt. Ltd., New Delhi.
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BLUE PRINT
Code number: **BO 8421**
Title of the paper: **Tools and Techniques in Plant Sciences**

Total marks for which the questions are to be asked (including bonus questions)	Number of hours	Module number
12	07	I
13	08	II
8	05	III
19	12	IV
21	13	V
23	15	VI
96	**60**	**TOTAL**
Maximum marks for the paper (Excluding bonus question): **70**		

PRACTICALS BO 8P4: Tools and Techniques in Plant Sciences

Total: 44 hours

1. Photomicrography and image analysis.
2. Working and applications of dissection microscope, stereomicroscope and light microscope; Camera lucida.
3. Phase contrast Microscope and Inverted microscope. Microtome.
4. Isolation of mycorrhizal spores by wet sieving and decanting method
5. Tissue maceration to identify VAM fungal colonization.
6. Centrifuges: types of rotors, centrifugation techniques (cell fractionation, density gradient, differential)
7. Extraction of pigments using Soxhlet apparatus.
8. Chromatography: paper, TLC, column chromatography.
9. Determination of absorption maxima of compounds extracted from plants.
10. Extraction of proteins and preparation of reagents for SDS-PAGE.
11. Separation of proteins using SDS-PAGE.

REFERENCES:

1. Sabari Ghosal & A. K. Srivastava (2009), Fundamentals of Bioanalytical techniques and instrumentation, PHI Learning Pvt. Ltd., New Delhi.
2. B. D. Hanes (1998), Gel electrophoresis of proteins – a practical approach, Third Edition.
3. K.L. Ghatak (2011), Techniques and Methods in Biology, PHI Learning Pvt. Ltd., New Delhi.
4. Sadasivam, S & Manickam, A. 1966. Biochemical methods (2nd ed.), New Agent Int. Publishers, New Delhi.

Course Outcomes: At the end of the Course, the Student

CO1	Have developed a sound knowledge in using the tools and techniques in Plant Sciences.
CO2	Have developed a very good understanding of principles, working and applications of the instruments used in Plant Sciences.
CO3	Are able to reinforce the techniques studied for identification, separation and purification of plant metabolites.
CO4	Are able to critically evaluate and design experiments used in Plant Sciences