ST. JOSEPH'S UNIVERSITY

BENGALURU-27

DEPARTMENT OF BOTANY

SYLLABUS FOR POSTGRADUATE PROGRAMME

For Batch 2023-2024

Part A			
1	Title of the Academic Program	MSc Botany	
2	Program Code	**(To be given by Examination Section)**	
3	Name of the University	St. Joseph's University	
4	Objective of the University	1. Academic Excellance 2. Character Formation 3. Social Concern	
5	Vision of the University	"Striving for a just, secular, democratic and economically sound society, which cares for the poor, the oppressed and the marginalized"	
6	Mission of the University	M1	St. Joseph's University seeks to form men and women who will be agents of change, committed to the creation of a society that is just, secular and democratic.
		M2	The education offered is oriented towards enabling students to strive for both academic and human excellence.
		M3	The college pursues academic excellence by providing a learning environment that constantly challenges the students and supports the ethical pursuit of intellectual curiosity and ceaseless enquiry.
		M4	Human excellence is promoted through courses and activities that help students achieve personal integrity and conscientise them to the injustice prevalent in society.
7	Name of the Degree	Master of Science (M.Sc.) in Botany	
8	Name of the Department offering the program	Botany	
9	Vision of the Department offering program	"The Department intends to inculcate in the students an interest to explore the world of Plants and contribute to the rapidly expanding field. We wish to offer the society, a generation of humble yet aspiring young minds eagerly striving towards unraveling the mystery of Plant Science"	
10	Mission of the Department offering program	• The Department of Botany aim at identifying one's potential to become a centre for augmenting and contributing continuously to the vibrant field of Botany. • We strive to create and provide an ambient learning atmosphere and prepare students for academia, industry and productive application of the knowledge in everyday life. • It emphasizes the impact of plants on environment and the human activities.	
11	Duration of the Program	2 years (Four semesters)	
12	Total No. of Credits	94	
13	Program Educational Objectives (PEOs)	PEO 1	
		PEO2	
		PEO 3	
		PEO4	

Programme Educational Objectives: PEOs are statements that describe Institution's Mission aligned with the programme 2-5 PEOs can be written.

- **Guidelines for the PEOs**

<table>
<tr><td colspan="4">
– PEOs should be consistent with the mission of the Institution
– The number of PEOs should be manageable
– PEOs should be achievable by the program
– PEOs should be specific to the program and not too broad
</td></tr>
<tr><td>14</td><td colspan="2">Graduation Attributes</td><td>The Following graduate attributes reflect the particular quality and feature or characteristics of an individual, that are expected to be acquired by a graduate through studies at St. Joseph's College.
• Disciplinary knowledge
• Communication Skills
• Critical thinking
• Problem solving
• Analytical reasoning
• Research-related skills
• Cooperation/Team work
• Reflective thinking
• Information/digital literacy
• Self-directed learning and Lifelong learner
• Multicultural competence
• Moral and ethical awareness/reasoning
• Leadership readiness/qualities
• International Outlook</td></tr>
<tr><td rowspan="4">15</td><td rowspan="4">Program Outcomes (POs)</td><td>PO1</td><td></td></tr>
<tr><td>PO2</td><td></td></tr>
<tr><td>PO3</td><td></td></tr>
<tr><td>PO4</td><td></td></tr>
<tr><td colspan="4">Programme Outcomes: POs are statements that describe what the students graduating from any of the educational Programmes should be able to do. 4-10 POs can be written

• Guidelines for the POs
– Program outcomes basically describe knowledge, skills and behavior of students as they progress through the program as well as by the time of graduation.
– POs should not be too broad
– They must be aligned with the Graduation Attributes</td></tr>
</table>

Part B

M.Sc. Botany Curriculum

Courses and course completion requirements	No. of credits
Botany	
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 7123	Microbiology, Mycology & Plant Pathology	60	04	04	30	70	100
Theory	BO 7223	Algae & Bryophytes	60	04	04	30	70	100
Theory	BO 7323	Pteridophytes and Gymnosperms	60	04	04	30	70	100
Theory	BO 7423	Taxonomy of Angiosperms and Economic Botany	60	04	04	30	70	100
Theory	BO 7523	Plant Breeding & Plant Propagation	60	04	04	30	70	100
Practical	BO 7P1	Microbiology, Mycology & Plant Pathology	88	04	02	15	35	50
Practical	BO 7P2	Algae & Bryophytes	88	04	02	15	35	50
Practical	BO 7P3	Pteridophytes and Gymnosperms	88	04	02	15	35	50
Practical	BO 7P4	Biostatistics & Bioinformatics	88	04	02	15	35	50
Practical	BO 7P5	Plant Breeding & Plant Propagation	88	04	02	15	35	50
Total Number of credits:			**30**					
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 8123	Pteridophytes & Gymnosperms	60	04	04	30	70	100
Theory	BO 8223	Biostatistics and Bioinformatics	60	04	04	30	70	100
Theory	BO 8323	Plant Morphogenesis and Embryology	60	04	04	30	70	100
Theory	BO 8423	Tools and Techniques in Plant Sciences	60	04	04	30	70	100
Theory	BO 8523	Plant Physiology and Metabolism	60	04	04	30	70	100
Practical	BO 8P1	Pteridophytes & Gymnosperms	88	04	02	15	35	50
Practical	BO 8P2	Biostatistics and Bioinformatics	88	04	02	15	35	50

Practical	BO 8P3	Plant Morphogenesis and Embryology	88	04	02	15	35	50
Practical	BO 8P4	Tools and Techniques in Plant Sciences	88	04	02	15	35	50
Practical	BO 8P5	Plant Physiology and Metabolism	88	04	02	15	35	50
Total Number of credits:			**30**					
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 9123	Ecology & Environmental Biology	60	04	04	30	70	100
Theory	BO 9223	Cell Biology, Genetics and Molecular Biology	60	04	04	30	70	100
Theory	BO 9323	Biotechnology	60	04	04	30	70	100
Theory (DE)	BODE 9423	Advanced Physiology (Elective)	60	05	04	30	70	100
Theory (DE)	BODE 9523	Plant Tissue Culture (Elective)	60	05	04	30	70	100
Note: Students can choose one of the departmental electives from BODE 9423 or BODE 9523								
Theory (DE)	BODE 9623	Microbiology (Elective)	60	05	04	30	70	100
Theory (DE)	BODE 9723	Systematics of Angiosperms (Elective)	60	05	04	30	70	100
Note: Students can choose one of the departmental electives from BODE 9623 or BODE 9723								
Practical	BO 9123	Ecology & Environmental Biology	88	04	02	15	35	50
Practical	BO 9223	Cell Biology, Genetics and Molecular Biology	88	04	02	15	35	50
Practical	BO 9323	Biotechnology	88	04	02	15	35	50
Practical	BODE 9423	Advanced Physiology (Elective)	88	04	02	15	35	50
Practical	BODE 9523	Plant Tissue Culture (Elective)	88	04	02	15	35	50
Practical	BODE 9623	Microbiology (Elective)	88	04	02	15	35	50
Practical	BODE 9723	Systematics of Angiosperms (Elective)	88	04	02	15	35	50
Total Number of credits:			**30**					

Semester 4	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
Research Project								
		IGNITORS/ OUTREACH						
Total Number of credits:			**04**					
Total No. of Credits : 94								
KEY WORDS: DE – Departmental Elective								

CORE COURSES (CC)	
Course Title	Code Number
Ecology & Environmental Biology	**BO 9221**

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 7123**
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 learn different techniques in Microbial study
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**

Introduction
Classification of Viruses: ICTV and Baltimore system
Methods of cultivation and purification of viruses
Viral capsomeres and envelope

Bacteria — **6**

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) — **2**

Unit II

Diseases & Defense — 18 Hrs

Host-Pathogen Interaction:

Host-microbe relationship (Symbiosis, Commensalism, Mutualism & Parasitism)
Infection Patterns; Pathogenicity; Virulence
Classification of Diseases (Epidemic, Endemic, Pandemic & Sporadic) — **7**
Disease Prognosis: Signs, Symptoms & Syndromes (self-study) — **2**

Epidemiology
Diseases in population
Reservoirs of infection
Mode of disease transmission; Herd immunity,
Nosocomial infections
Control of diseases: Vaccines, Toxoids.

Immune System: **9**

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

Unit III

Mycology 15 Hrs

Introduction to Mycology:

Characteristics, habit, habitat, somatic structures, reproduction and present status of fungi;
Classification of fungi by Ainsworth,1973, and Alexopoulos et al. 1996,
Phylogenetic classification of fungi by Mclaughlin et al 2001, Hibbett et al 2007, and Kirk et.al, 2008. 5
Fungal forms: salient features, classification and life cycles of Myxomycota, Mastigomycotina, Zygomycotina, Ascomycotina, Basidiomycotina and Deuteromycotina with suitable examples.
Sex hormones, heterothallism and parasexuality in fungi. Mycotoxins: useful and harmful effects, 8
Economic importance of fungi - (self-study) 2

Unit IV

Plant Pathology 15 Hrs

Introduction to Plant Diseases

History, concepts and scope of plant pathology; classification of plant diseases; Disease cycle and disease development; Pathogenicity test and Koch's postulates, effect disease on physiology of host, defense mechanisms in plants. Plant disease epidemics, disease indexing and fore casting.
Methods of plant disease management. 7

Study of plant diseases: Etiology, disease symptoms, vectors if any, disease cycle and control measures of following diseases:

Mycoplasma diseases: Grassy shoot of sugar cane, Yellow Dwarf in rice,
Viral diseases: Bunchy top of banana, Cotton leaf curl disease,
Bacterial diseases: Bacterial leaf blight of paddy, Black rot of crucifers,
Fungal Diseases: Late blight of Potato, Leaf curl of peach, Downy mildew of grapes, Coffee rust, Smut of maize, Wilt of cotton, Wood rotting. 6
(*Any of the above 2 diseases can be given as Self-study*) 2

NOTE: 8 hours of self-study assigned

REFERENCES:

1. Ajoy Paul, 2016. Text book of Immunology. Books and Allied Pvt. Ltd. Kolkatta.
2. Alexopoulus,C.J., Mims, C.W and Blackwell (1996) Introductory Mycology, 6th edition, Wiley Eastern Ltd., New Delhi.

3. Aneja, K.R. (1993) Experiments in Microbiology, plant pathology and tissue culture, Wishwa Prakashan, New Delhi.
4. Burnet, F.M. and Stanely, W.M. (1970) Biochemical biological and biophysical properties Vol-I general virology 3rd edition Academic Press, NY, London.
5. Conrat, F.H.; Kimball, P.C. and Jay, L. (1988) Virology, Prentice Hall, Englewood Cliff, New Jersey.
6. Deacon,J.W., 2006.Fungal Biology., Blackwell Publishers, USA.
7. N.J.Dimmock, A.J.Easton, K.N. Leppard, 2007, Modern Virology, VI Edition, Blackwell Publishing Company.
8. Kodo, C.I. and Agarwal, H.O. (1972) Principles and techniques in Plant Virology, Van Nostrand, Reinhold company
9. Pelczar, M.J. (Jr.) Chan, E.C.S. and Kreig, N.R. (1988) Microbiology, 5th edition McGraw Hall book company, Singapore.
10. Prescott, M.L., Harley, J.P. and Klein, D.A. (1990) Microbiology Wm C Brown publisher's, USA.
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14. Mehrotra R.S. and Aneja K.R.(1990)An introduction to Mycology. New Age International Publications.New Delhi
15. Webster.J. (1980) Introduction to Fungi. Cambridge Univ.Press, UK
16. Agrios G.2005.Plant pathology5th Ed.,Academic Press, USA
17. Black,J.G.,2008.Microbiology, 7th Ed.,John Wiley sons Asia Pvt. Ltd.
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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.
24. Ananthanarayanan, R. and Paniker, CKG. 2004. Textbook of Microbiology. Orient Longman Pvt. Ltd., New Delhi.
25. Arora, D. R. 2004. Textbook of Microbiology, CBS, New Delhi.
26. Sullia, S.B. and Shantharam, S. 2005. General Microbiology, Oxford and IBH, New Delhi.
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
15	12	I
23	18	II
19	15	III
19	15	IV
76	**60**	**TOTAL**
Maximum marks for the paper (Excluding bonus question): **50**		

BO 7P1: Microbiology, Mycology and Plant Pathology

Total: 44 Hours

1. Micrometry
2. Haemocytometer
3. Isolation, Culture and Staining Techniques of Bacteria & Fungi
4. Identification of Bacteria up to species level (any one) using Bergey's Manual
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, Tricholoma, Amanita, Lenzites, Polyporus, Trametes Ganoderma*. (Use recent classification)
7. Study of some Bacterial, Viral, Mycoplasma Diseases in Plants (*based on availability*)

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 7223**
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: Ecology of Algae: An account of environmental factors affecting the distribution of aquatic algae. Fresh water, Marine and Terrestrial Ecology. Algae of unusual habitats– cryophytes, halophytes, thermophilic algae, desert algae. Algae involved in biotic interactions with other organisms. 2

Unit II: 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 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 4

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

Unit VII: ***Applied Phycology: Uses of algae in agriculture (with special reference to use as biofertilizers), medicine and industries. Use of algae 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. 9

Unit III: Diversity in habitat, habit, morphology, anatomy and life cycle (with developmental details) of the following genera- *Plagiochasma, Porella, Notothylus, Sphagnum, Polytrichum*. 10

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

Unit V: General account of fossil bryophytes 2

Unit VI: ***Applied Bryology: Uses of bryophytes in medicine and industries (neutraceuticals, nanoparticle synthesis). Bryophytes as model organisms for research and as ecological indicators. (Self study)*** 4

NOTE: 8 hours of self-study can be assigned

BLUE PRINT
Code number: **BO 7223**
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		
2	2	I
6	5	II
8	6	III
8	6	IV
5	4	V
4	3	VI
5	4	VII
BRYOPHYTES		
4	3	I
11	9	II
12	10	III
3	2	IV
2	2	V
6	4	VI
76	**60**	**TOTAL**

Maximum marks for the paper (Excluding bonus question): **50**

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*
- *Asterella*
- *Porella*
- *Pallavicinia*
- *Riccardia*
- *Anthoceros*
- *Sphagnum*
- *Polytrichum*
- *Plagiochasma*
- *Targionia*

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

ST. JOSEPH'S UNIVERSITY, BENGALURU – 560027
I M.Sc. BOTANY PRACTICAL EXAMINATION
BO7P2: ALGAE AND BRYOPHYTES

Time: 4 hours **Max. Marks: 50**

1.	Make a micro-preparation of **A** and **B**. Identify, giving reasons with labeled diagrams. Leave the preparation the evaluation	2 × 5 = 10
2.	Identify, classify and write notes on **C, D, E, F** and **G** with diagrams	5 × 3 = 15

3.	Identify **H, I, J, K** and **L** with labeled diagrams	5 × 4 = 20
4.	Specimen submission (Algae and Bryophytes)	5

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

REFERENCES:

1. Bold, H.C., and Wynne, M.J.1985. Introduction to the algae: structure and reproduction. Prentice Hall, Englewood Cliffs, N.J.
2. Goffinet, B. and J. Shaw, 2009. Bryophyte biology. Cambridge University press, London.
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4. Dixon, P.S. 1973. Biology of the Rhodophyta. Oliver and Boyd, Edinburgh.
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6. Fritsch, F.E. 1945. Structure and reproduction of algae. Vols. I and II. Cambridge University Press, Cambridge.
7. Kingsley. R. 1998. Photosynthetic pigments of algae.
8. Kumar, H.D.1990.Introductory phycology. East West Pvt. Ltd. Bangalore
9. Round, F.E. 1973. Biology of the algae. Edward Arnold, London.
10. Smith, G.M. 1951. Manual of phycology, Chronica Botanica Publ. Co. Waltham, Mas.
11. Cavers, F. 1964. Inter-relationships of Bryophytes.
12. Chopra, R.N. and Kumar, P.K. 1988. Biology of bryophytes. New Age International Publishers, New Delhi.
13. Parihar, N.S. 1970. An introduction to Embryophyta. Vol. I Bryophyta. Central Book Depot, Allahabad.
14. Rashid, A. 1998. An Introduction to Bryophyta. Vikas Publishing house, New Delhi.

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17. Trivedi, P.C.2001. Algal biotechnology, Poiner publishers, Jaipur, India.

Course Outcomes and Course Content

Semester	I
Paper Code	**BO7323**
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 : Isoetales - *Isoetes*, Ophioglossales - *Ophioglossum*, Marattiales – *Marattia, Angiopteris,* Osmundales - *Osmunda*, Filicales -, *Gleichenia, Hymenophyllum, Pteris, Adiantum*, and Salviniales-*Salvinia.* 12

Unit III: Fossil Pteridophytes – Systemic position, Structure of sporophytes and gametophytes, Reproduction of the following: Psilophytales: *Horneophyton*, *Rhynia, Asteroxylon*, Lepidodendrales: *Lepidodendron, Lepidostrobus, Lepidocarpon* and Calamitales: *Calamites* and *Spenophyllum* 7

Unit IV: Evolutionary trends in Psilophytales, Marattiales, Filicales, Lepidodendrales and Sphenophilales, 5

Unit V: Application of Pteridophytes: *Food, Medicinal, Industrial, **(Self study)*** Biotechnological uses Micropropagation, Somatic embryogenesis, Vegetative propagation methods; Phytoecdysones in Pestiferous Insect Management
4

GYMNOSPERMS 30 Hrs

Unit I: *General characters of Gymnosperms.* Classification (Sporne 1974, Bhatnagar and Moitra 1996), *Gymnosperms of India: distribution and conservation status.* 3

Unit II: Diversity in morphology, anatomy and reproduction of the following orders:
Cycadales (*Cycas*), Ginkgoales, Coniferales (*Cedrus*), Taxales (*Taxus*), Gnetales (*Ephedra*, *Welwitschia*). 12

Unit III: Fossil Gymnosperms: Systemic position, Structure of sporophytes and gametophytes, Reproduction of the following Pteridospermales (*Medullosa*), Cycadeoideales (*Cycadeoidea*), 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. *Polyembryony in Gymnosperms* 2

Unit V: Applications of Gymnosperms in different fields – medicine (Cure, antimicrobial properties), Industry, Pollution control, micropropagation, synthetic seed technology. 4

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. Allahab.
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.
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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
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Gymnosperms

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

BLUEPRINT

Code number:**BO7323**

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		
2	2	I
16	12	II
9	7	III
6	5	IV
5	4	V
Gymnosperms		
4	3	I
15	12	II
8	6	III
6	5	IV
5	4	V
76	**60**	**TOTAL**
Maximum marks for the paper (Excluding bonus question):**50**		

BO 7P3: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, Salvinia and Azolla.
2. Fossil pteridophytes 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, Cardiocarpuss pinatus, Glossopteris, Vertebraria, Pentoxylon, Cornoconites.*

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. Allahab.
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8. Sundararajan, S. 1994.Introduction to Pteridophyta. New Age International Publishers.
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10. Pandey, B.P.2007.College Botany vol. II., S Chand and Company, Pvt. Ltd. New Delhi.
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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.
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8. Stewart WN and Rothwell GW. 1993. Paleobotany and the Evolution of Plants. Cambridge University Press, USA.
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10. Govil C.M. 2011. Gymnosperm. Krishna Prakashan Media.
11. Chamberlain CJ. 2009. Gymnosperms structure and evolution. University of Chicago Press, USA.

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	III
Paper Code	**BO 7423**
Paper Title	**Taxonomy of Angiosperms and Economic Botany**
Number of teaching hours per week	04
Total number of teaching hours per semester	60
Number of credits	04

Objectives of the Paper:

- To recognize and understand concepts involved in Plant Taxonomy.
- To learn plant distribution, diversity and identification of flowering plants.
- To identify and study economically important plants.

	Unit I: Taxonomy of Angiosperms	**50 hrs**
Chapter No. 1	**Systems of Classification and comparative study:** Engler & Prantl, Bessey, Hutchinson and. Brief account on APG IV classification Taxonomic literature - Floras, Monographs, Revisions, Indices and Journals. Taxonomic Keys. Field & Herbarium Methods and importance. *Brief highlight on National herbaria and Botanical Survey of India*	**8 + 1 hr**
Chapter No. 2	**Plant nomenclature:** ICN, Typification, Principles of priority and their limitations - Effective and valid publications – Authors Citations, Retention, choice and rejection of names	**5 hrs**
Chapter No. 3	**Role of the following in taxonomy:** Morphology, Anatomy, Palynology, Embryology, Cytology and Chemosystematics	**04 hrs**
Chapter No. 4	Salient features, comparative account and economic uses of the families **Monocotyledonae**: Commelinaceae, Zingiberaceae, and Arecaceae. **Dicotyledonae**: Santalaceae, Loranthaceae, Aristolochiaceae, Amaranthaceae, Nyctaginaceae, Moraceae, Nymphaeaceae, Magnoliaceae, Annonaceae, Myrtaceae, Lauraceae, Capparidaceae, Oxalidaceae, Geraniaceae, Rutaceae, Meliaceae, Tiliaceae, Sterculiaceae, Apocynaceae, Asclepiadaceae, Boraginaceae, Verbenaceae, Lamiaceae, Bignoniaceae, Acanthaceae, and Asteraceae. **Any 4 families can be chosen for self-study by concerned faculty*	**28 + 4 hrs**
	Unit II: Economic Botany	**10 hrs**
	Origin, Distribution, Botanical name, systematic position (Engler and Prantl system) & Economic uses of the following:	**7 + 3 hrs**

Chapter No. 5	**Fibre** - Cotton, Coir, Jute **Timber** - Rosewood, Teakwood and Sal Medicinal Plants- (i) **Drugs from roots**- Aconite, *Belladona, Sarpagandha*, *Ashwagandha*; (ii) **Drugs from underground stems**- Turmeric, Ginger, Onion, Garlic; (iii) **Drugs from bark**- Cinnamon, Quinine, Ashoka, Berberry; **Drugs from leaves**- *Aloe*, Holybasil, Vasaka, *Stramonium*; (v) **Drugs from stems and woods**- Ephedrine, Catechu, Digitalis, White Sandalwood (vi) **Spices and Condiments**- Asafoetida, Cinnamon, Clove, Cardamom, Saffron, Black Pepper, Anise, Coriander, Cumin, Fennel, Fenugreek, Poppy. (vii) **Latex yielding plant:** Para Rubber and India rubber (viii) **Biopesticides:** Tobacco and Neem (ix) **Essential oil**: Sandal wood, Eucalyptus, lemon-grass. Jasmine, Rosemary, Mint. (x) **Edible oil**: Linseed, Sunflower, Sesame & Groundnut (xi) **Biofuels**: *Jatropa, Pongamia* *Any 3 categories can be chosen for self-study by concerned faculty*	
References	• Benson, L.B., 1962. Plant Taxonomy: Methods and principles • Beck, C.B., (ed) 1976 Origin and early evolution of Angiosperms, Columbia University Press, New York • Bhattacharya, B., &Johri, B.M., (eds) 1988 Flowering Plants: Taxonomy and phylogeny, Narosa Publishing House, New Delhi • Carlquist, S., 1961 Comparative plant anatomy - A guide to taxonomic and evolutionary application of anatomical data in Angiosperms • Cronquist, A., 1988 The evolution and classification of flowering plants, 2nd ed., New York Botanical Garden, New York • Dahlgren., 1980 A revised system of classification of the Angiosperms. Bot. J. Linn. Soc. 80 : 91 – 124 • Davis, P.H., & Heywood, V.H., 1973 Principles of Angiosperm taxonomy. Robert E Kriegen Publ. Co., New York • Lawerence, F.H.M., 1951 Taxonomy of vascular plants. MacMillan, New York • Erdtman G., 1952 Pollen Morphology and plant taxonomy, ChronicaBotanica, Waltham, Maas • Heywood, V.H., & Moore D.M. (eds) 1984 Current concepts in plant taxonomy, Academic Press, London Nair, P.K.K., 1970 Pollen morphology of angiosperms: a	

	historical and phylogenetic study. Barnes and Noble, New York • Lam, H.J., 1959 Taxonomy: general principles and angiosperms. Vistas in Botany Vol. II page 3 - 75. • Radford, A.E., Dickinson, W.C., Massey, J.R., & Bell, C.R., 1974 Vascular Plant systematics, Harper & Row, New York • Smith, P.M. 1976 The chemotaxonomy of plants. Edward Arnold, London • Sneath, P.H.A., &Sokal R.R., 1973 Numerical taxonomy : The principles and practice of numerical classification. W.H. Freeman, San Francisco • Swain, T., (ed.) 1966 Comparative phytochemistry, Academic Press, New York • Turrill, W.B., (ed) 1964 Vistas in Botany Vol. IV : Recent researches in plant taxonomy, Pergamon Press, London • Yough, D.A., &Siegler, D.S. (eds) Phytochemistry and Angiosperm phytochemistry, Praeger Scientific, New York	

NOTE: Portions which are in italics are meant for self-study

BO 7P4	**Practical: Taxonomy of Angiosperms and Economic Botany**	
	• Construction of floral diagrams, descriptions using technical terms to bring out salient features of the taxa • Identification of economically important plants and plant products mentioned in the theory syllabus • **Study tour (mandatory)** Students must undertake a tour in the III Semester for not more than 5 days to study flora and submit 5 herbarium specimens, 15 digital herbarium specimen (hard (prints)/soft copy) and a tour report. To be submitted during practical examination.	

Course Outcomes and Course Content

Semester	I
Paper Code	**BO 7523**
Paper Title	**Plant Breeding & Plant Propagation**
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 application aspects of plant breeding and propagation.
- To be able to learn various plant breeding and plant propagation techniques and apply the same in the field of agriculture, horticulture, pomiculture and floriculture.
- To understand the process of production, management, harvesting and marketing of few selected flowers, fruits, medicinal and aromatic plants.
- To understand the challenges and opportunities in the field of plant breeding and propagation.

	PLANT BREEDING	**30 hrs**
Unit I	History and scope of plant breeding; Plant genetic resources; Sources of germplasm, Systematic evaluation and utilization,Germplasm conservation, Global and National organization forcrop improvements, pattern of evolution in crop plants. Introduction of plants and acclimatization	**06 hrs**
Unit II	Conventional breeding methods: Reproduction, genetic basis, sexual and asexual, apomixis, gene induction and significance in plant breeding. Domestication, plant introduction and acclimatization. Selectionin self, cross pollinated and vegetative propagated plants. *Hybridization: In self-pollinated, cross-pollinated and vegetatively propagated plants.* *Back cross: Technique and importance*	**07hrs** **+ 03 hrs**
Unit III	Marker Assisted Selection (MAS) in Plant breeding Resistance breeding: Disease, insects and drought, Types of resistance, genetics of host and parasite relationship, mechanism of drought resistance, breeding methods for disease, and drought resistance. *Heterosis breeding:* Inbreeding depression, Homozygous and heterozygous balance, genetic basis.	**08 + 1hrs**
Unit IV	Distant hybridization: Introduction, history and barriers.Techniques for production of distant hybrids. Quality seeds: Classes, production and maintenance. The Indian seed act.	**06 hrs**
	PLANT PROPAGATION	
Unit V	Basic concepts and principles of plant propagation.Propagating structures; Greenhouse/ Polyhouse/ Shade house Cladding materials (a) PVC film (b) Polypropylene sheets (c) Fibre-lass, (d) Shade net Miscellaneous propagating Structures (a) Misting unit (c) Nursery bed (d) Fluorescent light boxes (e) Propagating cases (f) Hardening tunnels **Media for Propagation** Qualities of an ideal rooting and growing media, selection criteriafor media, media for propagation and growing nursery plants (a) soil (b) sand (c) peat (d) sphagnum moss (e) vermiculite (f) perlite/ soilrite(h) leaf mold (i) saw dust and dry barks (j)coco peat **Horticultural tools and equipments** *Hand tools and power equipments (Self Study)*	**10 +** **2hrs**

	Methods of propagation Seed propagation, Methods of cuttings, grafting, budding and layering in ornamentals and fruit crops. Natural vegetative methods- underground, subaerial and aerial suckers, bulbs, Rhizomes, Stolons, Tubers, Corms, Runners, bulbils.	
Unit VI	**Floriculture** Indoor and outdoor cultivation methods and harvest of (i) Rose, (ii) Chrysanthemum, (iii) Carnation, (iv) Anthurium (v) Orchids and (vi) Gerbera; post, harvest storage of flowers, packing, transportation and marketing.	**08hrs**
Unit VII	**Pomiculture** Cultivation, harvest, post-harvest storage, fruit processing, packing, transportation and marketing of Grapes and Apple **Cultivation of medicinal and aromatic plants** Cultivation and propagation techniques of some important medicinal and aromatic plants; *Morinda citrifolia (Noni)* and *Pogostemon cablin (Pacholi)* *Rauwolfia serpntina and Cymbopogon citratus (Self Study)*	**06 + 2hrs**
References	• Poehlman, J.M., and Brothukar, I.B.H., 1998. Breeding of Asianplants. I.B.H. New Delhi. • Poehlman, J.M., and Sleper, D.A. 1999. Breeding field crops.Panima Publ. Crop New Delhi. • Singh, B.D.A 2000. Plant Breeding. Kalyani Publ. New Delhi. Simmonds, N.W. (ed.) 1986. Evolution of crop plants. Longmann Sci. Tech. Pub. England. • Khoklov, S.S. Apomixes and Plant breeding. Amerind, NewYork. • Sharma, J.R. 1994. Plant breeding. T.M.H. Publ. Comp. NewDelhi. • Frankel, R. and Bet Dagan. 1983. Heterosis. Springer verlag.Berlin. • Russel, E.G. 1978. Plant breeding for pest and disease resistance. Butterworth, London. • Sneep, J. and Hendriksen, A.S.T. (ed.) 1979. Plant breedingpreparations. Puduo. Wageningen, Netherlands. • Hartman, H.J. et al. 1990. Plant propagation - Principles andpractices. Prentice Hall, New Delhi. • Schwalz, M. 1975. Guide to commercial hydroponics, IsraelUniversity, Jerusalem. • Sharma, V.K. 1996. Plant nurseries, Techniques, production and management. Indian Pub. New Delhi.	

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Total marks for which the questions are to be asked (including bonus questions)	Number of hrs	Chapter/ Unit number
24	15	I
24	15	II
24	15	III

24	15	IV
96	**60**	**TOTAL**
Maximum marks for the paper (Excluding bonus question): **70**		

Practicals	**BO7P5: Plant Breeding & Plant Propagation**	**44 hours**

	• Plant breeders kit, Horticultural tools and equipment (Photographs)
	• Propagating structures; Greenhouse/ Polyhouse/ Shade house/ Vermicomposting pit
	• Estimation of Pollen viability by using (any 3 species)
	  o Trypan Blue Method
	  o Muntzing method
	• Estimation of seed viability by (any 3 species)
	  o TTC method
	  o Ferric chloride method
	  o Mechanical method
	• Vegetative propagation methods
	  o Layering (ground layering and air layering}
	  o Cutting
	  o Budding
	  o Grafting
	• Emasculation and Hybridization Technique
	• Visit to Lalbagh or International Flower Auction Bangalore (IFAB) Limited (8 hours)
	• Visit to IIHR (8 hours)	

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

CO1	Explain core concepts in Plant breeding and plant propagation.
CO2	Learn tools and techniques in plant breeding and plant propagation.
CO3	Students will learn indoor/outdoor cultivation methods and harvest of selected flowers, fruits, medicinal and aromatic plants.
CO4	Through practical exercises and field visits, students will understand the challenges and opportunities exist in the field of plant breeding and plant propagation.
CO5	Entrepreneur based teaching and learning process

Course Outcomes and Course Content

Semester	II
Paper Code	**BO8123**
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 structural organization.
Nodal Anatomy - Unilacunar, Trilacunar and Multilacunar nodes, Split-lateral condition, Root-stem transition.
Internal Structure of dicot and monocot stem; Types of Vascular bundles- collateral, bicollateral, concentric, medullary bundles, Internal Phloem; Internodal anatomy; ***(self study)*** 4 + 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. 4

Unit III: Shoot Apical Meristem (SAM): Structural organization; Tunica-Corpus theory, Cytohistological zonation, Apices with primary thickening meristem, summit meristem - Cyclic and Acyclic changes in shape and size of shoot apex during different phases of development.
Root Apical Meristem (RAM) - Apical cell theory, Histogen theory, Korper-Kappe theory, quiescent centre concept, promeristem concept. 8

Unit IV: Primary Xylem - Concepts of Protoxylem - metaxylem; Diversity in axial parenchyma distribution, diversity in ray system;
Vascular Cambium: Structure and activity, uniseriate / Multiseriate nature, cambium zone, types of diversion in the fusiform initials.
Wood anatomy: *Diversity in structure of wood: Heart wood, sap wood, growth rings, ring-porous wood: diffuse-porous wood* ***(self study)***; 6 + 2

Unit V: Anomalous structure in *Bignonia argentia, Mirabilis jalapa, Aristolochia indica, Beta vulgaris* root. 4

NOTE: 8 hours of self-study assigned

REFERENCES:

1. Agashe S N. 2006.Palynology and its application, Oxford & IBH Publishing Co. Pvt. Ltd. New Delhi.
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.
4. Erdtman G. 1957 "Pollen & spore Morphology / plant taxonomy Vol. 1 - V. Hafner Pub. Co. New York.
5. Shaw A B. 1964. "Time in Stratigraphy".
6. Wadia D N. 1957. "Geology of India".
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8. Steward AC. 1959 Plant life through the Ages. Hafner Publishing Company, New York. Pb.
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10. Steward A C. Fossil Plants (Vol. 1, 2, 3 and 4, 1989, 1910, 1977, 1919).
11. Surange K R, Lakhanpal R N, Baradwaj DC. 1974. Aspects and appraisal of Paleobotany, Birbal Sahni Institute of Paleobotany, Lucknow, 675, 77.
12. Stuart 1983. Paleobotany and Evolution of Plants.
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15. Ogden E C, Rayner G S. Manual for sampling Airborne Pollen. Hafner Press, Macmillan Publishing Co., Inc, New York.
16. Abraham F. 1982. Plant anatomy - II edition, Pergaon Press, Oxford.
17. Carlquist S. 1967. Comparative plant anatomy - Holt Reinert and Winston.
18. Cutter DG. 1971. Plant anatomy - Part I, Cell and Tissues Edward Arnold.
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21. EsauK. 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.

BLUEPRINT

Code number: **BO8123**

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
2	2	III
2	2	IV
3	2	V
PALYNOLOGY		
2	2	I
5	4	II
1	1	III
2	1	IV
4	3	V
5	4	VI
PLANT ANATOMY		
8	6	I
5	4	II
10	8	III
10	8	IV
5	4	V
76	**60**	**TOTAL**
Maximum marks for the paper (Excluding bonus question):**50**		

BO 8P1: 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
4. Study of pollen morphology of common angiosperm taxa from permanent slides.
5. Preparation of permanent pollen reference slides using acetolysis technique.

Plant Anatomy

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

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. Revised Edition 2009-2010.

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 ofPaleobotany, 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	II
Paper Code	**BO 8223**
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** **History of Biostatistics** *Contributions of Karl Pearson* *Contributions of Roland Fischer* *Contributions of Francis Galton* *Contributions of Prasanta Mahalanobis* Applications of Biostatistics **Concepts of Biostatistics** Descriptive & Inferential Statistics Population; Sample; Data Variables & Replications **Sampling techniques** Methods & Types of Sampling Random & Non-Random Sampling Sampling & Non-Sampling Errors **Study design** Concepts of Control Replicates & Randomization CRD & RCBD **Concepts & Problems** Measures of central tendency Mean, Median & Mode *(Problems and solutions related to mean, median and mode only)*	**10 + 3 Hrs**

Unit II	**Data Analysis & Representation** **Graphical Representations** Line diagrams; Bar diagrams; Histograms; Pie diagrams Frequency Polygons; Frequency Curves (Ogives) Stem & Leaf Chart ; Scatter Plot **Measures of dispersion** Variance & Standard Deviation Coefficient of Variation Skewness & Kurtosis **Correlation and Regression** Analysis of Correlation and Regression Coefficient of Correlation & Regression **Probability** Rules of Probability Normal**,** Poisson & Binomial distributions **Hypothesis Testing** Tests of significance Degrees of Freedom T-Test; *Chi-square test; ANOVA (Self Study)*	**15 + 2 Hrs**
Unit III	**Introduction to Bioinformatics** **History of Bioinformatics** Introduction to Computational Biology Applications & History of Bioinformatics Networking Standards & Types World Wide Web Java, Bio-Perl & Python programming languages **Databases** Database Structure, Classification & Growth Types of Biological Databases NCBI; EMBL; ExPASy; DrugBank; Array Express *Genome Online Database* *Human Genome Project & Its Significance (Self Study)*	**10 + 3 Hrs**
Unit IV	**Tools in Bioinformatics** **Genomics & Proteomics** Genomics: Introduction to Gene Sequencing Types of Gene Sequencing Methods Proteomics: Introduction to Experimental Methods & Protein Structure Protein-Ligand Interactions **Sequence Analysis** Sequence Alignment Pairwise & Multiple Sequence Alignments Needleman &Wuncsh ; Smith & Waterman algorithms BLAST Analysis Phylogenetic analysis Types of Phylogenetic Tree Tools of Phylogenetic Tree Analysis **Structural Analysis** PyMol Protein Structure Visualization	**17 Hrs**

	Tools for Protein Structure Analysis 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.

BLUE PRINT

Code number: **BO 8223**

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
16	13	I
22	17	II
16	13	III
22	17	IV
76	**60**	**TOTAL**
Maximum marks for the paper (Excluding bonus question): **50**		

BO 8P2: Biostatistics & Bioinformatics

Total: 44 hours

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

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

Course Outcomes and Course Content

Semester	II
Paper Code	**BO 8323**
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

24 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; *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). 8

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

36 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.

Discussion of research papers with specific examples of development.

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 cotton.

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, Composition of embryo* ***(Self study)***

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

9

NOTE: 8 hours of self-study assigned

BLUE PRINT

Code number: **BO 8323**

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	8	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 8P2: 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.
4. Johansen, D.A. 1950. Plant embryology, Chronica Botanica Co., Waltham, mass.
5. Johri B.M. (ed) 1984, Embryology of Angiosperms, Springler - verlag, Berlin.
6. Lyndon R.F 1990. Plant Development - The cellular basis, Unwin Hyman, London.
7. Maheswari P. 1950. An introduction to the embryology of Angiosperms, McGraw Hill, New York.
8. Maheshwari P (ed.) 1963. Recent advances in embryology, Int. Soc. Pl. Morphol. New York.
9. Raghvan V. 1976. Experimental embryogenesis in vascular plants, Cambridge University, Cambridge.
10. Raghavan V.R.2000. Developmental biology of flowering plants. Springer publications.
11. Sinnot E.W. 1960.Plant morphogenesis. Mc Graw Hill Book Company, INC, New York.
12. Steeves T.A. and Sussex I.M. 1989. Patterns in plant development, 2nd ed. Cambridge University Press, Cambridge.
13. Steward, F.C. 1968. Growth and Organization in plants, Addison - Wesley Pub. Co. U.S.A.
14. Johri B.M. 1982. Experimental embryology of vascular plants. Springer Verlag, Berlin.
15. Wardlaw 1968. Morphogenesis in plants, Methuen and Co.
16. Wareing P.F. and I.D.J. Phillips, 1978. The control of growth and differentiation in plants. Pergamon press, New York.

17. Mc Lean R.C. and W.R. Ivimey-Cook, 1951. Text book of theoretical botany, Vol. I. Longmans, Green and Co Ltd.
18. Weigel 1995. The genetics of flower development from floral induction to ovule morphogenesis. Annual review of Genetics. Vol.29.
19. Bernier G. 1988. The control of floral evocation and morphogenesis.Ann.Rev.Pl. Physiol. & Mol.Biol.Vol.39., 175-219.
20. Sharma, H.P.2009.Plant embryology classical and experimental. Narosa Publishing House, New Delhi.

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 8423**
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	**Research Methodology:** Components of a research paper. Writing references using Mendeley and Endnotes.	2 hrs
Unit II	**Microscopy, History and Introduction:** History of Microscopy. Properties of light in relation to microscopy - Wavelength, resolution, reflection, transmission, absorption, refraction, diffraction; Relationship between revolving 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.	7 hrs
Unit III	**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.	7+1 hrs
Unit IV	**Microtomy:** Microtomy and ultra-microtomy techniques, fixatives, clearing agents, dehydrants, stains, staining schedules, freeze fracturing, freeze etching; cryopreservation.	5 hrs

Unit V	**Centrifugation:** Principle and types of centrifuges and rotors; techniques of centrifugation, *brief account of cell fractionation (self-study).* **Spectroscopy:** Visible, UV, IR, NMR, AAS, XRD. **Radiobiology:** radioisotope techniques (GM counter, scintillation and autoradiography).	12+1 hrs
Unit VI	**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.	11+1 hrs
Unit VII	**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)*** **Photoluminescence:** *Principles and applications of phosphorescence, fluorescence and bioluminescence.* ***(self-study)*** **Biomechanics:** Principles and applications of biomechanics, nano-technology and protein engineering	8+5 hrs

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.
3. Gerald Karp (2007), Cell Biology, Seventh Edition, John Wiley & Sons.
4. C.E. Banwell, C.N., and McCash E.M. 1994. Fundamentals of Molecular spectroscopy, (4th edition), Tata McGraw - Hill, Publishing Co. Ltd

5. Narayanan, P. 2000. Essential of Biophysics. New Agri. International Publishers.
6. Berlyn, G.P. &Miksche, J.P. 1976: Botanical Microtechnique and cytochemistry, Iowa State Univ. Press.
7. De Robertis, E.O.P., & De Robertis, E.M.R. Jr. 1987. Cell and molecular biology, 8th ed., B.I. Wasberly Pvt. Ltd., New Delhi.
8. Dhopte, A, M. 2002. Principles and Techniques for plant scientists, Agrobios (India).
9. Grey, P. (ed.) 1973. Encyclopedia of microscopy and Microtechnique, van Nostrand Reinhold Co., New York.
10. Jensen, W.A. 1962. Botanical histochemistry, Freeman & Co., San-Fransisco.
11. Johansen, D.A. 1940. Botanical Microtechnique, McGraw Hill, New York.
12. Kaul, A.D., Singh, N., Sonkusare, A., Kumar, P. &Wadhwa, S.S. 1997. Design of an Atomic force microscope for topographic studies, Curr. Sci. 73 (9): 738 - 743.
13. Purvis, M.J., Collins, D.C., & Wallis, D. 1966. Laboratory techniques in Botany (2nd ed.) Butterworths, London Running.
14. M.P., Clark, S.E. & Mayerowitzz, E.M. 1995. Confocal microscopy of shoot apex, in methods in cell biology, Vol. 49, pp. 355 - 366, Academic Press, New York.
15. Sanderson, J.B. 1994. Biological microtechniques, BIOS Sci. Pub., London.
16. Wilson, K., &Goulding, K.H. (eds.) 1986. A biologist's guide to principles and techniques of practical biochemistry (3rded). Cambridge Univ. Press.
17. Schmidt R.F., Thews G. Human Physiology. Berlin Heidelberg, 1989 (in English)
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19. Wilson, K. and Walker, J. 2010. Principles and techniques of Biochemistry and Molecular biology.Cambridge University Press.
20. Cox, G. 2007. Optical imaging techniques in cell biology. Taylor and Francis, LLC.
21. Murphy, D. B. and M. W. Davidson. 2013. Fundamentals of light microscopy and electronic imaging. Wiley Blackwell.
22. Ruzin,S. E.1999. Plant microtechnique and Microscopy. Oxford University Press.
23. Homes, B. D. Gel electrophoresis of proteins -a practical approach.

BLUE PRINT
Code number: **BO 8423**
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
3	02	I
9	07	II
11	08	III
6	05	IV
15	12	V
16	13	VI
16	13	VII
76	**60**	**TOTAL**
Maximum marks for the paper (Excluding bonus question): **50**		

BO 8P4: Tools and Techniques in Plant Sciences

Total: 44 hours

1. Writing references using Mendeley and Endnotes. 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. Tissue maceration to identify VAM fungal colonization.
5. Centrifuges: types of rotors, centrifugation techniques (cell fractionation, density gradient, differential)
6. Extraction of pigments using Soxhlet apparatus.
7. Chromatography: paper, TLC, column chromatography.
8. Determination of absorption maxima of compounds extracted from plants.
9. Extraction of proteins and preparation of reagents for SDS-PAGE.
10. Separation of proteins using SDS-PAGE.
11. Revision and attestation of records.

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

Course Outcomes and Course Content

Semester	II
Paper Code	**BO 8523**
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 (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), vein loading and unloading.

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 and their regulation. 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 regulation, Alternative respiration. Glyoxylate pathway. 7

Unit VII: Nitrogen metabolism: Biological Nitrogen fixation, Symbiotic nitrogen fixation in legumes - nodule formation and nod factors, 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.

*Agricultural applications of the above mentioned hormones (**Self study)***

6 + 1

NOTE: 8 hours of self-study assigned

REFERENCES:

1. Meyer B.S. and Anderson D.B., 2017, Plant Physiology, Agri-biovet Press, New Delhi.
2. L.Taiz and E.Zeiger, I.M.Moller and A. Murphy, 2015, Plant Physiology 6th Ed., Sinauer Associates, Inc, USA.
3. W.G.Hopkins and N.P.A.Huner, 2009, Introduction of plant physiology, 4th Edition, John Wiley and Sons, Inc.
4. Conn, EE., Stumpf, PF., Bruening, G and Doi. RH. 1987. Outlines of Biochemistry, John Wiley and Sons, New York, Chichester, Bisbane, Toronoto and Singapore.
5. Hall, DO and Rao KK 1999, Photosynthesis 6th edition, published in association with Institute of Biology, Cambridge University Press.

6. Moore, TC, 1989. Biochemistry and Physiology of Plant Hormones (Second edition) Springer - Verlag, New York, USA
7. Hopkins W G (1995) Introduction to Plant Physiology, John Wiley & Sons, INC, New York, USA.
8. Stumpf, PK, and Conn, EE (eds.) 1988. The Biochemistry of Plants - A comprehensive treatise, Academic Press, New York.
9. Taiz L and Zeiger E. 1998. Plant Physiology 2nd Ed. Sinauer Associates, Inc., Publishers, Massachusetts, USA.
10. R.G.S. Bidwell. 1974. Plant physiology. Macmillan Publishing company, New York.
11. Wilkins, M.B.(Ed.)1989. Advanced plant physiology. Pitman publishing Ltd., London.

BLUE PRINT

Code number: **BO 8523**

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
4	3	I
8	6	II
11	9	III
11	9	IV
19	15	V
9	7	VI
5	4	VII
9	7	VII
76	**60**	**TOTAL**
Maximum marks for the paper (Excluding bonus question): **76**		

BO 8P5: Plant Physiology and Metabolism

Total: 44 Hours

1. Preparation of solutions and reagents

2. Determination of water potential by gravimetric method
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