

SYLLABUS for M. Sc. BOTANY
Choice Based Credit System (Semester Pattern)
Rashtrasant Tukadoji Maharaj Nagpur University, Nagpur
Effective from 2018-2019

Candidates opting for this course are advised to go through the direction relating to the course “DIRECTION RELATING TO THE EXAMINATION LEADING TO THE DEGREE OF MASTER OF SCIENCE, SEMESTER PATTERN (CHOICE BASED CREDIT SYSTEM) AND DEGREE OF MASTER OF SCIENCE AND TECHNOLOGY (APPLIED GEOLOGY). SEMESTER PATTERN, (CHOICE BASED CREDIT SYSTEM) (FACULTY OF SCIENCE & TECHNOLOGY)” which is available on R. T. M. Nagpur University website.

The direction will provide details on admission criteria, rules for ATKT, scheme of examination, absorption scheme for CBS students into CBCS pattern, elective papers, foundation course papers, subject centric papers, coding pattern, pattern of question papers, practicals, distribution of marks, seminars, project work, internal assessment, calculation of SGPA and CGPA, etc.

Scheme of teaching and examination under semester pattern Choice Based Credit System (CBCS) for M.Sc. Program in Botany

M. Sc. Botany Semester I											
Code	Theory / Practical	Teaching scheme (Hours / Week)			Credits	Examination Scheme					
		Theory	Practical	Total		Duration in hrs.	Max. Marks		Total Marks	Minimum Passing Marks	
							External Marks	Internal Ass		Theory	Practical
Core 1 (1T1)	Paper 1 - Microbiology, Algae and Fungi	4	-	4	4	3	80	20	100	40	
Core 2 (1T2)	Paper 2 - Bryophytes & Pteridophytes	4	-	4	4	3	80	20	100	40	
Core 3 (1T3)	Paper 3 - Paleobotany and Gymnosperms	4	-	4	4	3	80	20	100	40	
Core 4 (1T4)	Paper 4 - Cytology and Genetics	4	-	4	4	3	80	20	100	40	
Pract. Core 1 & 2 (1P1)	Practical 1- Algae, fungi, Bryophytes	-	8	8	4	6	100	-	100		40
Pract. Core 3 & 4 (1P2)	Practical 2- Pteridophytes, Gymnosperms,	-	8	8	4	6	100	-	100		40

	Paleobotany, Cytology & Genetics										
Seminar 1 (1S1)	Seminar 1	2	-	2	1			25	25	10	
	TOTAL	18	16	34	25		520	105	625	170	80

M. Sc. Botany Semester II											
Code	Theory / Practical	Teaching scheme (Hours / Week)			Credits	Examination Scheme					
		Theory	Practical	Total		Duration in hrs.	Max. Marks		Total Marks	Minimum Passing Marks	
							External Marks	Internal Assesmt.		Theory	Practical
Core 5 (2T1)	Paper 5 – Plant Physiology and Biochemistry	4	-	4	4	3	80	20	100	40	
Core 6 (2T2)	Paper 6 – Plant Development and Reproduction	4	-	4	4	3	80	20	100	40	
Core 7 (2T3)	Paper 1 – Cell and Molecular Biology-I	4	-	4	4	3	80	20	100	40	
Core 8 (2T4)	Paper 8- Angiosperms-I and Ethnobotany	4	-	4	4	3	80	20	100	40	
Pract. Core 5 & 6 (2P1)	Practical 3- Plant Physiology, Plant Biochem., Plant Development & Reproduction	-	8	8	4	6	100	-	100		40
Pract. Core 7 & 8 (2P2)	Practical 4- Cell and Molecular Biology I, Angiosperms I	-	8	8	4	6	100	-	100		40
Seminar 2 (2S1)	Seminar 2	2	-	2	1			25	25	10	
	TOTAL	18	16	34	25		520	105	625	170	80

M. Sc. Botany Semester III											
Code	Theory / Practical	Teaching scheme (Hours / Week)			Credits	Examination Scheme					
		Theory	Practical	Total		Duration in hrs.	Max. Marks		Total Marks	Minimum Passing Marks	
							External Marks	Internal Ass		Theory	Practical
Core 9 (3T1)	Paper 9 – Plant Ecology and Conservation Biology	4	-	4	4	3	80	20	100	40	
Core 10 (3T2)	Paper 10 - Angiosperms-II	4	-	4	4	3	80	20	100	40	
Core Elective 1 (3T3)	Paper 11 - Elective -I	4	-	4	4	3	80	20	100	40	
Foundation Course 1 / Core Subject Centric 1 (3T4)	Paper 12 - Foundation I / Subject Centric I	4	-	4	4	3	80	20	100	40	
Pract. Core 9 & 10 (3P1)	Practical 5- Plant Ecology and Conservation Biology and Angiosperms II	-	8	8	4	6	100	-	100		40
Pract. Core Elective 1 (3P2)	Practical 6- Elective	-	8	8	4	6	100	-	100		40
Seminar 3 (3S1)	Seminar 3	2	-	2	1			25	25	10	
	TOTAL	18	16	34	25		520	105	625	170	80

M. Sc. Botany Semester IV											
Code	Theory / Practical	Teaching scheme (Hours / Week)			Credits	Examination Scheme					
		Theory	Practical	Total		Duration in hrs.	Max. Marks		Total Marks	Minimum Passing Marks	
							External Marks	Internal Ass		Theory	Practical
Core 11 (4T1)	Paper 13 – Cell and Molecular Biology-II	4	-	4	4	3	80	20	100	40	
Core 12 (4T2)	Paper 14 - Plant Biotechnology and Plant Breeding	4	-	4	4	3	80	20	100	40	
Core Elective 2 (4T3)	Paper 15 - Elective II	4	-	4	4	3	80	20	100	40	
Foundation Course 2 / Core Subject Centric 2 (4T4)	Paper 16 - Foundation II / Subject Centric I	4	-	4	4	3	80	20	100	40	
Pract. Core 11, 12 & Elective 2 (4P1)	Practical 7- Cell and Molecular Biology-II, Plant Biotechnology and Plant Breeding	-	8	8	4	6	100	-	100		40
Project (4 PROJ 1)	Practical 8 - Project	-	8	8	4	6	100	-	100		40
Seminar 4 (4S1)	Seminar 4	2	-	2	1			25	25	10	
	TOTAL	18	16	34	25		520	105	625	170	80

**SEMESTER I
PRACTICAL (1P1)**

Time : 6 Hours

Full marks : 100

- | | |
|---|----|
| Q. 1 To identify the given Cyanobacterial material A. | 10 |
| Q.2 To identify two algal forms B, C, from the given mixture. | 10 |
| Q.3 To identify the given fungal culture D | 10 |
| Q. 4 To identify the given plant pathogen in the given material E. | 10 |
| Q. 5 To prepare a temporary micropreparation of the given Bryophytic Material F and identify it | 10 |
| Q. 6 Comment on the given spot G (Cyanobacteria/Bacteria), H (Algae), I (Fungi), J (Bryophyte) | 10 |
| Q.7 Viva-voce | 20 |
| Q. 8 Practical Record and tour report | 20 |

**SEMESTER I
PRACTICAL (1P2)**

Time : 6 Hours

Full marks : 100

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|--|----|
| Q. 1 To prepare a double stained micropreparation of the given Pteridophytic material A and identify it. | 10 |
| Q.2 To prepare a double stained micropreparation of the given gymnospermic material B and identify it. | 10 |
| Q.3 Comment on the given fossil specimen C | 10 |
| Q. 4 One experiment from Cytology and Genetics D | 10 |
| Q. 5 Comment on the given spot E (Pteridophyte), F (Gymnosperm), G (Fossils), H (Cytology/Genetics) | 20 |
| Q.6 Viva-voce | 20 |
| Q. 7 Practical Record and tour report | 20 |

**SEMESTER II
PRACTICAL (2P1)**

Time : 6 Hours

Full marks : 100

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|--|----|
| Q. 1 To perform the given physiological experiment A and report the findings | 10 |
| Q.2 To quantify the given metabolite in the given sample B | 5 |
| Q.3 To study the cytohistological zonation in SAM of given material C | 10 |
| Q. 4 To perform the given exercise based on plant development D | 10 |
| Q. 5 Write a note on given stage of micro-or megasporogenesis E | 10 |
| Q. 6 Spotting: F (Physiology), G (Plant development), H (Reproduction) | 15 |
| Q. 7 Viva-voce | 20 |
| Q. 8 Practical Record | 20 |

**SEMESTER II
PRACTICAL (2P2)**

Time : 6 Hours

Full marks : 100

Q. 1	One experiment from paper VII A	15
Q.2	One experiment from paper VII B	10
Q.3	One experiment from paper VIII C	15
Q. 4	One experiment from paper VIII D	10
Q. 5	Spotting	10
Q. 6	Viva-voce	20
Q. 7	Practical Record and field diary	20

**SEMESTER III
PRACTICAL (3P1)**

Time : 6 Hours

Full marks : 100

Q. 1 To perform the given ecological exercise A	15
Q.2 To solve the given statistical problem B	15
Q.3 To describe the given plant in technical language with floral formula and floral diagram C	10
Q. 4 To prepare the generic/family key D	5
Q. 5 To identify species of the given plant using Flora	5
Q. 7 Spotting	10
Q. 8 Viva-voce	20
Q. 9 Practical Record	20

PRACTICAL 3P2 (ELECTIVE)
MOLECULAR BIOLOGY AND PLANT BIOTECHNOLOGY

Time: 6 Hours

Full Marks: 100

1. One Major Experiment from Group A	15
2. One Minor Experiment from Group A	10
3. One Major Experiment from Group B	15
4. One Minor Experiment from Group B	10
5. Identification and comments on given two spots	10
6. Practical record	20
7. Viva-voce	20

PRACTICAL 3P2 (ELECTIVE)
APPLIED MYCOLOGY AND PLANT PATHOLOGY

Time: 6 Hours

Full Marks: 100

1. Identify giving salient characters of fungi from the given culture. (A)	10
2. Identification of given diseased material, their symptoms and characters.(B)	10
3. Effects of different concentrations of sugar solutions on the conidial germination and presentation of data on graph paper.	10
4. Drawing of camera lucida diagram of the given fungus/microorganism.	10
5. Demonstration of pure culture techniques /transfer techniques.	10
6. Spotting (two spots)	10
7. Practical record, Herbarium and field report	20
8. Viva-voce	20

PRACTICAL 3P2 (ELECTIVE)
REPRODUCTIVE BIOLOGY OF ANGIOSPERMS

Time: 6 Hours

Full Marks: 100

- | | |
|---|----|
| 1. Dissect and mount the endothecium/endosperm from the given materials. | 10 |
| 2. Dissect and mount given stage of embryo from the material. | 10 |
| 3. In vitro pollen germination percentage and pollen tube growth. Record the data under given conditions. | 10 |
| 4. Study the Morphology of pollen grain. | 10 |
| 5. A) Localize the Biochemical compounds in a given plant material. | 5 |
| B) Draw the camera lucida figure of a embryological stage focused under the microscope. | 5 |
| 6. Identification and comment on the given spots.(2 Spots) | 10 |
| 7. Practical record & field Report. | 20 |
| 8. Viva-voce | 20 |

PRACTICAL 3P2 (ELECTIVE)
PLANT PHYSIOLOGY

Time: 6 Hours

Full Marks: 100

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|--|----|
| 1. One Major Experiment from Special paper- I A | 15 |
| 2. One Minor Experiment from Special paper- IB | 10 |
| 3. One Major Experiment from Special paper- II C | 15 |
| 4. One Minor Experiment from Special paper- IID | 10 |
| 5. Identification and comments on given two spots (E, F) | 10 |
| 6. Practical record and Project/field report. | 20 |
| 7. Viva-voce | 20 |

PRACTICAL 3P2 (ELECTIVE)
PALYNOLOGY

Time: 6 Hours

Full Marks: 100

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|--|----|
| 1. Pollen preparation by standard method/s - Section 'A'. | 15 |
| 2. Any ONE experiment from Section B. | 15 |
| 3. Any ONE experiment from Section C. | 15 |
| 4. Any ONE experiment from Section A/B/C (Minor)
(Other than asked in Question 1 - 3) | 5 |
| 5. Spotting | 10 |
| 6. Practical Record, Permanent slides & field record | 20 |
| 7. Viva-voce | 20 |

PRACTICAL 3P2 (ELECTIVE)
PALAEOBOTANY

Time: 6 Hours

Full Marks: 100

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|---|----|
| 1. Preparation of ground section slide of a given fossil specimen | 10 |
| 2. Preparation of slide by maceration technique | 10 |
| 3. Preparation of a peel section of given fossil specimen. Draw a well Labelled Diagram and comment | 10 |
| 4. Write monograph on the given specimen | 10 |
| 5. Comment on Given Fossil wood | 10 |
| 6. Comment on the spots | 10 |
| 7. Practical record and Field Report | 20 |
| 8. Viva-Voce | 20 |

SEMESTER IV
PRACTICAL (4P1)

Time : 6 Hours

Full marks : 100

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|---------------------------------------|----|
| Q. 1 One experiment from Paper XIII A | 15 |
| Q.2 One experiment from Paper XIII B | 10 |
| Q.3 One experiment from Paper XIV C | 15 |
| Q. 4 One experiment from Paper XIV D | 10 |
| Q. 5 Spotting from Elective Paper II | 10 |
| Q. 6 Viva-voce | 20 |
| Q. 7 Practical record | 20 |

M. Sc. Botany Syllabus

Semester I

1T1- Core : Microbiology, Algae and Fungi

Module I: Prokaryotes and viruses

General Microbiology: History- Contributions made by Leeuwenhoek, Pasteur, Robert Hook, Jenner, Waksman, Iwanowsky. Koch's Postulates.

Bacteria: Structure, morphology, reproduction.

Viruses: General account; Morphology and ultrastructure of TMV, Bacteriophage; Introduction to viroids, prions and interferon.

Archaeobacteria and bacteria: General account; ultrastructure, nutrition and reproduction, biology and economic importance; Cyanobacteria: *Microcystis*, *Lyngbya*, *Nostoc*, *Scytonema*, *Gloeotrichia* and *Stigonema*.

Module II: Phycology

Criteria for classification of algae: Chlorophyta, Charophyta, Xanthophyta, Bacillariophyta, Pheophyta and Rhodophyta; pigments, reserved food, flagella.

Algae in diversified habitats (terrestrial, freshwater, marine), thallus organization; cell ultrastructure; reproduction (vegetative, asexual, sexual); algal blooms, algalbiofertilizers; algae as a food, feed and uses in industry.

Module III: Mycology

General account: Classification of Fungi (recent trends and criteria used in classification); Physiology of Fungi (with reference to biotrophs, hemibiotrophs, symbionts); Fungal Cytology; Heterothallism, heterokaryosis, parasexual cycle.

Comparative study, classification and evolutionary trends in the following: Myxomycota: Protist characters and general account with special reference to *Physarium* and *Plasmodiophora*
Eumycota: i. Oomycetes: *Saprolegnia*, *Synchytrium*, *Phytophthora*, *Peronospora*,
ii. Zygomycetes: *Mucor*, *Rhizopus*, *Syncephalastrum*, *Cunninghamella*

Module IV: Mycology and plant pathology

Mycology contd....: Comparative study, classification and evolutionary trends in the following:
iii. Ascomycetes: *Phyllactinia*, *Chaetomium*, *Xylaria*

iv. Basidiomycetes: *Melampsora*, *Puccinia*, *Ravenelia*, *Ustilago*

v. Deuteromycetes: *Cercospora*, *Helminthosporium*, *Fusarium*, *Colletotrichum*.

Plant Pathology: Symptomology, histopathology, etiology and identification of diseases with reference to following fungal, bacterial and viral diseases (Paddy blast, wheat rust, bunt of wheat, smut of jowar, black arm of cotton, red rot of sugarcane, citrus canker, gummosis, leaf curl of papaya, potato blight.)

Practicals

Classification and type study of the following classes:

Prochlorophyta: *Prochloron*, Chlorophyta: *Pandorina*, *Eudorina*, *Stigeoclonium*, *Ulva*, *Chlorella*, *Scenedesmus*, *Caulerpa*, *Valonia*, *Acetabularia*; Phaeophyta: *Spacelaria*, *Padina*, *Turbinaria*; Rhodophyta: *Nemalion*, *Gelidium*, *Gracilaria*, *Corallina*, *Polysiphonia*; Euglenophyta: *Euglena*, *Phacus*; Bacillariophyta: *Cyclotella*, *Synedra*, *Cymbella*, *Navicula*, *Gomphonema*.

Morphological Studies of Fungi (any 15 of the following)

Stemonitis, Perenospora, Phytophthora, Albugo, Mucor, Rhizopus, Yeast, Aspergillus, Penicillium, Chaetomium, Taphrina, Peziza, Erysiphe, Phyllactenia, Uncinula, Melamosora, Uromyces, Drechslera, Ravenallia, Ustilago, Polyporus, Morchella, Cyathus, Alternaria, Helminthosporium, Curvularia, Colletotrichum, Phoma, Plasmodiophora, Cercospora, Fusarium, Claviceps.

Symptomology of some diseased plants (any 7 of the following).

White rust of Crucifers, Downy mildew, powdery mildew, Rusts, Smuts, Ergot, Groundnut leaf spot (Tikka disease), False smut of paddy, red rot of Sugarcane, Wilt disease, Citrus canker, Angular leaf spot of cotton, Potato blight, Leaf mosaic of bhindi/ papaya, Leaf curl of tomato/Potato/Papaya, Little leaf of brinjal.

Identification of Fungal cultures (Any 5)

Rhizopus, Mucor, Aspergillus, Penicillium, Drechslera, Curvularia, Phoma, Colletotrichum, Alternaria, Helminthosporium.

Field study: For collection and studying fungal flora

Suggested Readings:

1. Kumar HD (1988) Introductory Phycology. Affiliated East-West Press Ltd. New Delhi
2. Morris I (1986) Introduction to the Algae. Cambridge University Press, UK
3. Round FE 1986 The Biology of Algae. Cambridge University Press, UK
4. Mandahar CL 1978 Introduction to Plant Viruses. Chand & Co. Ltd., New Delhi
5. Agrios, G.N. (1980) Plant Pathology, academic Press, INC, New York.
6. Ainsworth, G.C. and A.S.Sussman (eds). The Fungi, An advance Treatise Vol.I, II, III & IV Academic Press, New York.
7. Alexopoulos, C.J. (1962). Introductory Mycology John Wiley Eastern Pvt.Ltd.
8. Alexopoulos, C.J. and Mims C.W. (1979). Introductory Mycology 3rd Edition, John Wiley and Sons, Inc. Wiley, New York.
9. Alexopoulos, C.J., Mims and Black well (1996) 4th ed. John Wiley and Sons, Inc. Wiley, New York
10. Aneja, K.R. (1993) Experimental in Microbiology, Plant Pathology & Tissue Culture, Wiswa Prakashan, New Delhi.
11. Bessey, E.A. (1950) Morphology and Taxonomy of Fungi. The Blakiston co. Philadelphia.
12. Bilgrami, K.S. and H.C.Dube (1985) A text Book of Modern Plant Pathology, Vikas Publication House, New Delhi.
13. Barnett, J.H. (1968) Fundamentals of Mycology. The English Language Book Society and Edward Arnold Publication, Limited.
14. Dube, R.C. and D.K.Maheshwari (1999) A.Text Book of microbiology, S.Chand & Co. Ltd.
15. Dube, R.C. and D.K.Maheshwari (2000) Practical Microbiology -S.Chand & Co. Ltd.
16. Gupta, V.K. and M.K.Behl (1994) Indian Plant Viruses and Mycoplasma Kalyani Publishers, 1/1, Rejinder Nagar, Ludhiana.
17. Jha, D.K. (1993) A Text Book of Seed Pathology, Vikas Publication House.
18. Mehrotra, R.S. (1989) Plant Pathology, Tata McGraw Hill.
19. Mehrotra, R.S. and K.R.Aneja (1998) An Introduction to Mycology, New Age Intermediate Press.
20. Pelzer, M.J. , Jr.Cahn, E.C.S. and N.R.Krieg (1993) Microbiology, Tata McGraw Hill.
21. Preece and Dickeson. Ecology of leaf surface microorganism Academic Press, New York.
22. Rangaswamy, G. and A.Mahadevan (1999) Diseases of Crop Plant in India, Prentice Hall of India.

23. Raychoudhari, S.P. and Nariani, T.K. (1977) Virus and Mycoplasma Diseases of Plant in India, Oxford and IBH Publication Co.
24. Schlegel, H.G. (1996) General Microbiology, 7th Edition, Cambridge University Press.
25. Snowdon, A.L. (1991) A colour Atlas of Post harvest diseases & disorders of fruits & vegetables Vol.I & II Wolfe Scientific, London.
26. On line Journals available on UGC -VSAT

Semester I

1T2- Core: Bryophytes & Pteridophytes

Module I: Bryophytes

General characters, distribution, classification, ecology of Bryophytes, fossil history of bryophytes, cytology of bryophytes, regeneration in bryophytes, evolution of sporophyte-Retrogressive and Progressive theory.

Module II: Bryophytes contd.....

General account of-Hepaticopsida: Sphaerocarpaceae, Takakiales; Anthocerotopsida: Anthocerotales; Bryopsida: Sphagnales, Polytrichales.

Module III: Pteridophytes

General characters, distribution, classification, evolution of stele, heterospory and seed habit, apospory and apogamy; Important contributions of Indian Pteridologists, General account of Ryniopsida, Psilopsida, Lycopsidea [protolpidodendrales, Lycopodiales, Selaginiales, Isoetales].

Module IV: Pteridophytes contd...

General account and evolutionary trends of Sphenopsida [Hymeniales, Equisetales], Filicopsida [Ophioglossales, Filicales, Salviniaceae, Marsileales], Tracheophyta [Progymnospermopsida].

Practicals

Bryophytes:

Study of morphological and reproductive characters of representative members mentioned in the syllabus using cleared whole mount preparations, dissections and sections. Preparation of permanent slides is necessary.

Study of bryophytes in their natural habitats.

Botanical excursion outside the state is compulsory to study the bryophytes in their natural conditions.

Pteridophytes:

Study of fossil forms (specimens and permanent micropreparations).

Study of living forms: Morphological, anatomical and reproductive characters of the forms mentioned in the syllabus. Anatomical characters to be studied either by taking free hand sections (t.s./l.s.) and by observing the permanent micropreparations. Preparations of permanent slides are essential.

Study of pteridophytes in their natural habitats.

Botanical excursion outside the state is compulsory to study the pteridophytes in their natural conditions.

Suggested Readings

1. Andrews H.N. Jr. (1961) Studies in Paleobotany (Jonh Wiley & Sons, New York)
2. Arnold C.A. (1947) An introduction to Paleobotany (McGraw Hill, New York)

3. Banks H.P. (1968) The early history of Land plants. In evolution and environment, ed. E.T. Drake. New Haven: Yale Univ. Press, pp, 73-107.
4. Banks H.P. (1970) Evolution and plants of past. (Belmont, California, Wadsworth).
5. Banks, H. P. (1975). Reclassification of Psilophyta, Taxon.24, 401-13.
6. Berrie, G. K. (1963). Cytology and Phylogeny of liverwoets. Evolution 17, 347-357.
7. Bierhorst D.W (1971) Morphology of vascular plants, New York (Mac Millan)
8. Campbell, D. H. (1961). The evolution of the Land Plants (central Book Depot, Allahabad)
9. Cavers, F. (1910). The interrelationship of Bryophyta I-IV. New Phytologist.
10. Cavers, F. (1911). The interrelationship of Bryophyta VII-IX. New Phytologist.
11. Chrysler M.A. (1910) The fertile spike in Ophioglossaceae. Ann. Bot. 24:1-18.
12. Delevoryas T. (1962) Morphology and Evolution of fossil plants (Holt, Rinehart and Winston, New York).
13. Eames A.J (1936) Morphology of vascular plants, lower groups (McGraw Hill, New York).
14. Foster A.S. and E.M Gifford Jr. (1959) Comparative morphology of vascular plants Freeman, San Fransisco.
15. Grolle, R. (1963). Takakia in Himalayas, Ost. Bot. Zeitscher, 110:444-447.
16. Gupta K.M. (1962) Marsilea, Botanical monograph no. 2 (CSIR, New Delhi).
17. Ingold, C. T. (1939). Spores discharge in land plants (Oxford London)
18. Kashyap S.R. (1929). Liverworts of the western Himalayas and The Punjab Plain 1 (Chronica Botanica)
19. Kashyap S.R. (1933). Liverworts of the western Himalayas and The Punjab Plain 2 (Chronica Botanica)
20. Lacey, W. A. (1969). Fossil Bryophytes. Biological Reviews, 44, 189-205.
21. Mehra, P.N. and O. N. Handoo (1953). Morphology of Anthoceros erectus and A. himalayensis and the phylogeny of the anthocerotales. Bot. Gaz. 114:371-382.
22. Parihar N. S. (1976). An introduction to Embryophyta, Bryophyta (Central Book House, Allahabad)
23. Parihar N.S. (1977) The biology and morphology of the Pteridophytes (Central Book Depot, Allahabad).
24. Pichi-Sermolli REG (1959) Pteridophyta in vistas in botany, WB Turrill, ed. (Pergamon Press, London) pp 421-493.
25. Proskauer J. (1951). Study in Anthocerotales, III, The Bryologist 53, 165-172.
26. Puri Prem (1985) Bryophytes-A broad perspective.
27. Ramanujam CGK (1992) Origin and evolution of lycopods Paleobotanist 41, 51-57.
28. Rashid A. (1982) (4th edn) An introduction to pteridophyta (Vikas Publ House Pvt Ltd.)
29. Schuster R. (1966). The Hepaticae and Anthocerotae of North America. East of the Hundredth meridian, Newyork (Colombia University Press).
30. Scott D.H. (1908) Studies in fossil botany. London, Black Part 2.
31. Scott D.H. (1920-1923) Studies in fossil botany. (A & C Black London.)
32. Sharma O.P (1996) Textbook of pteridophyta (Mac Millan India Ltd, New Delhi)
33. Smith A. J. E. (1986). Bryophyte phylogeny fact or Fiction? Journal of Bryology, 14, 83-89.
34. Smith G. M. (1955). Cryptogamic Botany-vol. 2 Bryophyta and Pteridophyta (McGraw Hill Book company, Newyork)
35. Smith W.N. and G. W. Rothwell (1993). Paleobotany and the evolution of plants (Cambridge Univ. press)
36. Sporne K.R. (1962) The morphology of pteridophyta (Hutchinson Univ. Library, London)
37. Steil W.N. (1939) Apogamy, Apospory and Parthenogenesis in the pteridophyta, Bot. rev, 5, 433-453.
38. Steward W.N. (1983) Paleobotany and the evolution of plants. ed. New York, (Cambridge Univ. press)

39. Surange K.R and S. Chandra (1972) Fructification of Glossipteridae from India, *Paleobotanist* 21, 1-17.
40. Taylor T.N. (1988) the origin of land plants-Some answers more questions, *Taxon*, 37, 805-33.
41. Udar Ram (1970) An introduction to bryophyte (Shashidhar malviya Prakashan, Lucknow)
42. Udar Ram, Srivastava S.C. and Kumar Dinesh (1970) Genus *Buxbaumia* in India, *Curr. Sci. (India)* 39, 14-15.
43. Walton J. (1925) Carboniferous Bryophyta I. Hepaticae. *Annals of Botany*, 39, 563-72.
44. Walton J. (1928) Carboniferous Bryophyta II. Hepaticae & Musci. *Annals of Botany*, 42, 707-16.
45. Walton J. (1940) An introduction to the study of fossil plants. A& C Black, London.
46. Watson E.V. (1967) The structure and life of Bryophytes, 2nd ed, London, Hutchinson.
47. Wilson C.W. (1942) The telome theory and the origin of the stamen. *Am. J Bot.*, 29, 759-764.
48. Zimmermann W. (1952) Main results of the "Telome theory". *The Paleobotanist, Birbal Sahni Memorial Volume*, 456-70.

Semester I

1T3- Core: Paleobotany and Gymnosperms

Module I: Paleobotany

Introduction; Plant fossils- Preservation, preparation, age determination, geological time scale; Fossil record- systematics, reconstruction and nomenclature; Applied aspects of paleobotany.

Module II: Gymnosperms

General account; distribution (living, Fossil); origin; systems of classification; economic importance.

Comparative morphology and evolutionary tendencies of:

1. Pteridospermales- Lyginopteridaceae (*Calymotheca hoeninghausii*, *Heterangium*, *Spherostoma*); Medullosaceae (*Medullosa*, *Trignocarpus*).
2. Cycadales- Cycadaceae; Fossil history (*Baenia*, *Nilssonina*, *Androstrobus*)
3. Cycadeoidales- Williamsoniaceae, Cycadoideaceae

Module III: Gymnosperms contd...

General account and relationships of- Cordaitales, Caytoniales, Glossopteridales, Pentoxylales, Gnetales

Module IV: Gymnosperms contd...

Ginkgoales (*Ginkgo*, *Baiera*, *Trichopitys*); Coniferales (General characters, Embryogeny and phylogeny, evolution of ovuliferous scales, phylogeny); Taxales (*Taxus*, taxonomic position of taxales with respect to coniferales)

Laboratory exercise

Comparative Study of vegetative and reproductive parts of: *Cycas*, *Zamia*, *Cedrus*, *Abies*, *Pinus*, *Cupressus*, *Cryptomeria*, *Taxodium*, *Podocarpus*, *Agathis*, *Thuja*, *Gnetum*, *Ephedra*, *Juniperus*, *Cephalotaxus*, *Taxus*. Permanent micropreparations to be submitted by the students.

Ginkgo: Morphology to be studied from Museum specimens & anatomy from permanent slides only.

Study of important fossil gymnosperms from material and permanent slides.

Visit to palaeobotanical Institutes, localities and collection of specimens.

Field visits to ecologically different localities to study living gymnosperms.

Suggested Reading

1. Stewart, W.N. and Rothwell G.W. (1993), Palaeobotany and the Evolution of Plants, Cambridge University Press.
2. Foster A.S. & Gifford F.M. (1967): Comparative morphology of vascular plants, Freeman Publishers, San Francisco.
3. Eames, A.J.(1974): Morphology of Vascular Plants-lower groups, Tata Mc-Graw Hill publishing Co., New Delhi.
4. Arnold, C.A. (1947): Introduction to Palaeobotany, Mc-Graw Hill Book Co. Inc., New York and London.
5. Kubitzki K. (1990), The families and genera of vascular plants Pteridophytes and Gymnosperms, Springer Verlag, New York
6. Agashe, S.N. (1995), Palaeobotany, Oxford & IBH, New Delhi.
7. Biswas, C & Johri, B.N. (2004), The Gymnosperms, Narosa Publishing House, New Delhi.
8. Coulter J.M. & Chamberlain C.J.(1978): Morphology of Gymnosperms, Central Book Depot, Allahabad.
9. Kakkar, R.K.and Kakkar, B.R. (1995), The Gymnosperms (Fossils & Living), Central Publishing House, Allahabad.
10. Sharma O.P. (2002) Gymnosperms, Pragati Prakashan, Meerut.
11. Siddiqui, K.A. (2002) Elements of Palaeobotany, Kitab Mahal, Allahabad.
12. Bhatnagar, S.P. and Moitra A. (1996), Gymnosperms, New Age International Pvt. Ltd., New Delhi.
13. Singh, H. (1978), Embryology of Gymnosperms, Encyclopedia of Plant Anatomy X, Gebryder, Bortragear, Berlin.
14. Pant, D.D. (2003): Cycas and allied Cycadophytes, BSIP, Publications.
15. Bierhorst D.W. (1971): Morphology of vascular plants McMillan, New York.
16. Thomas, B.A. & Spicer R.A. (1987): The Evolution and Palaeobiology of land plants. Discordies Press, Fortland, USA.
17. Spicer, R.A. & Thomas, B.A. (1986) Systematic and taxonomic approaches in Palaeobotany. Systematic Association Special Volume.
18. Chamberlain C.J. (1986); Gymnosperms, structure and Evolution, CBS publishers and distributors, New Delhi.
19. On line Journals available on UGC -VSAT

Semester I

1T4- Core: Cytology and Genetics

Module I

Mendel's laws of inheritance; Deviations from Mendel's findings: incomplete dominance, co-dominance, penetrance, expressivity, multiple alleles and isoalleles (example Corn, *Drosophila* and *Nicotiana*), gene interactions (non-epistatic and epistatic), Linkage; Chromosome theory of inheritance; Modifiers, suppressors and pleiotropic genes; multigene families (globin and immunoglobulin genes); sex determination in plants, *Drosophila*, *C. elegans*.

Module II

Cytoplasmic inheritance and maternal effect

Chromatin organization: Chromosome structure and packaging of DNA, molecular organization of centromere and telomere, rRNA genes, euchromatin and heterochromatin;

Karyotype analysis and evolution, banding patterns; C-value paradox, Cot curve and its significance; specialized types of chromosomes: polytene, lampbrush, B-chromosome, sex chromosome; molecular basis of chromosome pairing.

Module III

Structural and numerical (heteroploidy) changes in chromosomes; origin, breeding behaviour of duplications, deficiency, inversion and translocation heterozygotes; effect of aneuploidy on plants; transmission of trisomics and monosomics and their use in chromosome mapping; complex translocation heterozygotes, translocation tester sets; Robertsonian translocation.

Population genetics: Hardy-Weinberg equilibrium; Factors affecting Hardy-Weinberg equilibrium; Quantitative trait loci (Kernel colour in wheat, corolla length in *Nicotiana longifera*).

Module IV

Mutations: Spontaneous and induced; physical and chemical mutagens- classification, mode of action; molecular basis of gene mutations; transposable genetic elements; site directed mutagenesis- definition, applications and PCR based oligonucleotide mutagenesis; role of mutations in crop improvement; induction of polyploidy

Epigenetics: Introduction; histone code; base modification; paramutations in maize; Callipygh sheep; Epigenetics and Lamarckism; Epigenome and epigenomics (Introduction).

Practicals

1. To study cell division (mitosis and meiosis) in the given material.
2. To study the effect of mutagen treatment on germination and seedling height.
3. To study effect of mutagen on the rate of cell division.
4. To study effect of mutagen on genetic material by scoring the chromosomal aberrations.
5. To study the translocation heterozygote in *Rheo discolor* or any other suitable material.
6. To study polytene chromosomes in *Chironomas* larvae.
7. To solve the given problems on interaction of genes (atleast five).
8. To study the karyotype of given organism.
9. To study the chiasma frequency in the given material.
10. To solve the given problem on population genetics (atleast three).

Suggested Reading

Gupta P K 2007 Genetics: Classical to Modern. Rastogi Publications, Meerut.

Hexter W and Yost Jr. H T 1977 The Science of Genetics. Prentice Hall of India Pvt. Ltd., New Delhi.

Hartl D L and Jones E W 1998 Genetics: Principles and Analysis (4thed.). Jones and Barflett Publishers, USA.

Khush G S 1973 Cytogenetics of Aneuploids. Academic press, New York.

Snustad D P and Simmons M J 2000 Principles of Genetics (2nded.) John Wiley and Son Inc., USA.

Semester II

2T1- Core: Plant Physiology and Biochemistry

Module-I

The Scope of plant physiology

Photosynthesis: Evolution of photosynthetic apparatus, pigments, Light, light harvesting complex, Mechanism of electron transport, Photo protective mechanism, CO₂ fixation, C₃, C₄ and CAM pathway, Photorespiration, the chemiosmotic-coupling hypothesis and ATP Synthesis, , ATP Synthesis in chloroplast

Respiration:- introduction, ,Glycolysis, Citric acid cycle, oxidative pentose phosphate pathway, Plant mitochondrial electron transport and ATP synthesis (oxidative phosphorylation) alternate oxidase.

Module-II

Plant hormones:- biosynthesis, storage , breakdown and transport of hormones, physiological effect and mechanism of action of hormones auxins, gibberellins and cytokinine

Sensory photobiology:- structure, function and mechanism of phytochromes, cryptochromes and phototropins, stomatal movement. Photoperiodism and biological clock

Module-III

Enzymes: Nomenclature and classification of Enzymes enzyme kinetics, Michaelis –Menten equation, mode and mechanism of Enzyme action (Regulation of Enzyme activity), Activators & Inhibitors of enzymes, properties of Enzymes, factors affecting Enzyme activity, isozymes.

Solute transport and photo-assimilate translocation:-uptake transport and translocation of water, ion, solutes and macromolecules from soil through cell, across membranes, through xylem and phloem , transpiration, mechanism of loading and unloading of photo -assimilates

Module –IV

Carbohydrate Metabolism:Composition, structure and function of carbohydrates, synthesis of starch and

Sucrose, catabolism (degradation) of starch and sucrose

Lipid Metabolism:Composition, structure and function of lipids, fatty acid biosynthesis, membrane Storage lipids.

Protein metabolism: Composition, structure (Ramchandra plot. secondary, tertiary and quaternary structure)and function of Proteins

Metabolism of amino acids: Composition, structure and function of amino acids, amino acid biosynthesis in Plants.

Nitrogen metabolism: Nitrate and ammonium assimilation

Secondary metabolites: Biosynthesis of terpenes, phenols. Nitrogenous compounds and their roles

Suggested laboratory exercises

1. To study the effect of time and enzyme concentration on the rate of reaction of enzyme (e.g. phosphatase, nitrate reductase).
2. To study the effect of substrate concentration on activity of enzyme and determination of its K_m value.
3. Demonstration of the substrate inducibility of the enzyme nitrate reductase.
4. Determination of succinate dehydrogenase activity, its kinetics and sensitivity to inhibitors.

5. To determine the total carbohydrate content in the given sample
6. Estimation of Pectic Substances-gravimetric method .
7. To prove Berr-Lambert's law using a suitable solution.
8. Extraction of chloroplast pigments from leaves and preparation of the absorption spectrum of chlorophyll and carotenoids.
9. To determine the chlorophyll a/ chlorophyll b ratio in C3 and C4 plants.
10. Isolation of intact chloroplasts and estimation of chloroplast proteins by spot protein assay.
11. Preparation of standard curve of protein (BSA) and estimation of protein content in extracts of plant material by Lowry's or Bradford's method.
12. Preparation of Leaf Protein Concentrates from green vegetables.
13. Determination of reducing sugars by Nelson – Somogyi Method.

Suggested reading (for laboratory exercises)

- 1 Bajracharya, D. 1999. Experiments in Plant Physiology: A Laboratory Manual. Narosa Publishing House, New Delhi.
- 2 Cooper, T.G. 1977. Tools in Biochemistry. John Wiley, New York, USA.
- 3 Copeland, R.A. 1996. Enzymes: A Practical Introduction to Structure, Mechanism and Data Analysis. VCH Publishers, New York.
- 4 Dennison C. 1999. A guide to Protein Isolation. Kluwer Academic Publishers, Dordrecht, The Netherlands.
- 5 Devi, P. 2000. Principles and Methods of Plant Molecular Biology, Biochemistry and Genetics. Agrobios, Jodhpur, India.
- 6 Dryer, R. L. and Lata, G. F. 1989. Experimental Biochemistry. Oxford University Press, New York.
- 7 Hames, B.D. (Ed.). 1998. Gel Electrophoresis of Proteins: A Practical Approach, 8th edition. PAS, Oxford University Press, Oxford, UK.
- 8 Harborne, T.C. 1981. Phytochemical Methods: A Guide to Modern Techniques of Plants Analysis. Chapman & Hall, London.
- 9 Moore, T.C. 1974. Research Experiences in Plant Physiology: A Laboratory Manual. Springer-Verlag, Berlin.
- 10 Ninfia, A. J. and Ballou, D. P. 1998. Fundamental Laboratory Approaches for Biochemistry and Biotechnology. Fitzgerald Science Press, Inc., Maryland, USA.
- 11 Plummer, D.F. 1988. An Introduction to Practical Biochemistry. Tata McGraw-Hill Publishing Co. Ltd., New Delhi.
- 12 Scott, R.P.W. 1995. Techniques and Practice of Chromatography. Marcel Dekker, Inc., New York.
- 13 Wilson, K. and Goulding, K.H. (Eds), 1986. A Biologists Guide to Principles and Techniques of Practical Biochemistry. Edward Arnold, London, UK.
- 14 Wilson, K. and Walker, J. 1994. Practical Biochemistry: Principles and Techniques, 4th edition. Cambridge University Press, Cambridge, UK.
- 15 Sadasivam and Manikam: Biochemical Methods, New Age International (p) Limited Publishers 4835/24, Ansari Road, Daryaganj, New Delhi-110002

Suggested readings (for theory)

- 1 Buchanan, B. B., Gruissem, W. and Jones, R.L. 1989. Biochemistry and Molecular Biology of plants. American Society of Plant Physiologists, Maryland, USA.
- 2 Dennis, D.T., Turpin, D. H., Lefebvre, D.D. and Layzell, D.B. (eds). 1997. Plant Metabolism (2nd Ed.) Longman, Essex, England.

- 3 Gaiston, A.W.1989. Life Processes in Plants. Scientific American Library, Springer-Verlag, New York, USA.
- 4 Hooykass P.J.J., Hall, M. A. and Libbenga, K.R.(eds).1999. Biochemistry and Molecular Biology of plant Horm. Elsevier, Amsterdam, The Netherlands.
- 5 Hopkins, W.G. 1995. Introduction to Plant Physiology. John Wiley & Sons, Inc., New York, USA.
- 6 Jones R, Ougham H, Thomas H and Waaland S 2013 The Molecular life of plants. Wiley-Blackwell Publ., USA
- 6 Lodish, H., Berk, A., Zipursky S.L., Matsudaira, P., Baltimore, D and Darnell, J. 2000. Molecular Cell Biology (4th ed). W. H. Freeman and Company. New York, USA.
- 7 Moore, T.C. 1989. Biochemistry and Physiology of Plant Hormones (2nd ed). Springer-Verlag, New York, USA.
- 8 Nobel, P.S.1999. Physicochemical and Environmental Plant Physiology (2nd ed). Academic Press, Diego, USA.
- 9 Salisbury, F.B. and Ross, C.W.1992: Plant Physiology (4th ed). Wadsworth Publishing Co., California, USA.
- 10 Singhal G.S., Renger, G., Sopory, S.K., Irrgang, K.D. and Govindjee.1999: Concepts in Photobiol Photosynthesis and Photomorphogenesis. Narosa Publishing House, New Delhi.
- 11 Taiz, L. and Zeiger, E. 1998: Plant Physiology. Sinauer Associates, Inc., Publishers, Massachus, USA.
- 12 Thomas, B. and Vince-Prue, D. 1997: Photoperiodism in Plants (2nd ed). Academic Press, San Diego, USA.
- 13 Westhoff, P. 1998: Molecular Plant Development: From gene to plant. Oxford University Press, Oxford, UK.
- 14 Dey, P. M. And Harborne, J. B. 2000: Plant Biochemistry, Harcourt Asia PTE Ltd. A Harcourt Publishers International Company, 583 Orchard Road 09-01 Forum Singapore
- 15 Ranjan, purohit, Prasad 2003: Plant Hormones Action and Application, Agrobios(India), agro house, behind Nasrani cinema Chopasani Road, Jodhpur -34

Semester -II

2T2- Core: Plant Development and Reproduction

Module I: Plant development

Plant growth kinetics and patterns of growth.

Seedling growth: Tropisms; Photomorphogenesis of seedling; hormonal control of seedling growth.

Shoot Development: Organization of shoot apical meristem (SAM); cytological and molecular analysis of SAM; regulation of cell fate in meristem; tissue differentiation in the shoot.

Phytohormones: Classification, chemical nature and their role in plant development.

Module II: Plant development contd.....

Leaf growth and differentiation: Determination; phyllotaxy; control of leaf form; differentiation of epidermis (with special reference to stomata & trichomes) and mesophyll.

Root Development: Organization of root apical meristem (RAM); vascular tissue differentiation; lateral root hairs; root microbe interactions.

Flower Development: Physiology of flowering, florigen concept and photoperiodism, Genetics of floral organ differentiation; homeotic mutants in *Arabidopsis* and *Antirrhinum*.

Pollination mechanisms and vectors.

Module III: Reproduction

Male Gametophyte: Structure of anther, microsporogenesis, tapetum; pollen development and gene expression; male sterility; sperm dimorphism; pollen germination; pollen tube growth and guidance.

Female Gametophyte: Ovule types; megasporogenesis; organization of embryo sac; structure of embryo sac cells.

Pollen-pistil interaction, self-incompatibility and fertilization; Structure of the pistil; pollen-stigma interactions, double fertilization; *in vitro* fertilization.

Module IV: Reproduction contd.....

Seed Development and fruit growth: Endosperm development; embryogenesis; ultrastructure and nuclear cytology; storage proteins of endosperm and embryo; polyembryony; apomixes; embryo.

Fruit development and growth

Latent life: Dormancy; Importance and types of dormancy; seed dormancy; overcoming seed dormancy; bud dormancy.

Senescence and Programmed Cell Death (PCD): Basic concepts; types of cell death, PCD in life cycle of plants; metabolic changes associated with senescence and its regulations; influence of hormones and environmental factors on senescence.

Suggested readings

- 1) Bhojwani, S.S. and Bhatnagar, S.P. 2000. The Embryology of Angiosperms (4th revised and enlarged edition). Vikas Publishing House, New Delhi.
- 2) Fageri, K. and Van der Pol, L. 1979. The Principles of Pollination Ecology. Pergamon Press, Oxford.
- 3) Fahn, A. 1982. Plant Anatomy, (3rd edition). Pergamon Press, Oxford.
- 4) Fosket, D.E. 1994. Plant Growth and Development. A molecular Approach. Academic Press, San Diego.
- 5) Howell, S.H. 1998, Molecular Genetics of Plant Development. Cambridge University Press, Cambridge.
- 6) Leins, P., Tucker, S.C. and Endress, P.K. 1988. Aspects of Floral Development. J. Cramer, Germany.
- 7) Lyndon, R.F., 1990. Plant Development. The Cellular Basis. Unwin Hyman, London.
- 8) Murphy, T.M. and Thompson, W.F. 1988. Molecular Plant Development. Prentice Hall, New Jersey.
- 9) Proctor, M. and Yeo, P. 1973. The Pollination of Flowers. William Collins Sons, London.
- 10) Raghavan, V. 1997. Molecular Embryology of Flowering Plants. Cambridge University Press, Cambridge.
- 11) Raghavan, V. 1999. Developmental Biology of Flowering Plants. Springer -Verlag, New York.
- 12) Raven, P.H., Evert, R.F. and Eichhorn, S.E. 1992. Biology of Plants (5th Edition). Worth, New York.
- 13) Steeves, T.A. and Sussex, I.M. 1989. Patterns in Plant Development (2nd edition). Cambridge University Press, Cambridge.
- 14) Sedgely, M. and Griffin, A.R. 1989. Sexual Reproduction of Tree Crops, Academic Press, London.
- 15) Waisel, Y., Eshel, A. and Kafkaki, U. (eds) 1996. Plant Roots: The Hidden Hall (2nd edition.) Marcel Dekker, New York.

- 16) Shivanna, K.R. and Sawhney, V.K. (eds) 1997. Pollen Biotechnology for Crop Production and Improvement, Cambridge University Press, Cambridge.
- 17) Shivana, K.R. and Rangaswamy, N.S. 1992. Pollen Biology: A Laboratory Manual. Springer-Verlag, Berlin.
- 18) Shivana, K.R. and Johri, B.M. 1985. The Angiosperm Pollen: Structure and Function. Wiley Eastern Ltd., New York.
- 19) The Plant Cell. Special issue on Reproductive Biology of Plants, Vol. 5(10) 1993. The American Society of Plant Physiologists, Rockville, Maryland, USA.
- 20) On line Journals available on UGC -VSAT

Suggested Laboratory / Field Exercises (Any 12)

1. Tissue systems, meristem, vascular and cork cambium.
2. Internal structure of root, stem and leaf (dicot and monocot), advanced secondary growth in dicot stem and root.
3. Anomalies in primary and secondary structure of stem.
4. Study of living shoot apices by dissections using aquatic plants such as *Ceratophyllum* and *Hydrilla*.
5. Study of cytohistological zonation in the shoot apical meristem (SAM) in sectioned and double-stained permanent slides of a suitable plant such as *Coleus*, *Kalanchoe*, Tobacco.
6. Examination of shoot apices in a monocotyledon in both T.S. and L.S. to show the origin and arrangement of leaf primordia.
7. Study of alternate and distichous, alternate and superposed, opposite and superposed; opposite and decussate leaf arrangement.
8. Examination of rosette plants (*Launaea*, *Mollugo*, *Raphanus*, *Hyoscyamus* etc.) and induction of bolting under natural conditions as well as by GA treatment.
9. Microscopic examination of vertical sections of leaves such as *Cleome*, *Nerium*, Maize and Wheat to understand the internal structure of leaf tissues and trichomes, glands etc. Also study the C3 and C4 leaf anatomy of plant.
10. Study of epidermal peels of leaves such as *Coccinia*, *Gaillardia*, *Tradescantia*, *Thunbergia*, etc. to study the development and final structure of stomata and prepare stomatal index. Demonstration of the effect of ABA on stomatal closure.
11. Study of whole roots in monocots and dicots. Examination of L.S. of root from permanent preparation to understand the organization of root apical meristem and its derivatives. (use maize, aerial roots of banyan, *Pistia*, *Jussieua* etc.).
12. Origin of lateral roots.
13. Study of leguminous roots with different types of nodules.
14. Study of microsporogenesis and gametogenesis in sections of anthers.
15. Examination of modes of anther dehiscence and collection of pollen grains for microscopic examination (Maize, Grasses, *Crotolaria*, *Tradescantia*, *Brassica*, *Petunia*, *Solanum melongena*, etc.)
13. Tests for pollen viability using stains and in vitro germination. Pollen germination using hanging drop and sitting drop cultures, suspension culture and surface culture.
14. Estimating percentage and average pollen tube length *in vitro*.
15. Role of transcription and translation inhibitors on pollen germination and pollen tube growth.
16. Pollen-pistil interaction, self-incompatibility, *in vitro* pollination.
17. Study of ovules in cleared preparations; study of monosporic, bisporic and tetrasporic types of embryo sac development through examination of permanent stained serial sections.
18. Field study of several types of flower with different pollination mechanisms (wind pollination, thrips pollination, bee/butterfly pollination, bird pollination).

19. Emasculation, bagging and hand pollination to study pollen germination, seed set and fruit development using self compatible and obligate outcrossing systems.
20. Study of cleistogamous flowers and their adaptations.
21. Study of nuclear and cellular endosperm through dissections and staining.
22. Isolation of zygotic globular, heart-shaped, torpedo stage and mature embryos from suitable seeds and polyembryony in citrus, jamun (*Syzygium cumini*) etc. by dissections.
23. Study of seed dormancy and methods to break dormancy.

Semester II

2T3 - Core: Cell and Molecular Biology-I

Module I:

Cell wall: Structure; function; biogenesis and growth.

Plasma membrane: Membrane architecture (fluid mosaic model); sites for ATPases; membrane transport-ion carriers, channels, pumps and aquaporins; receptors.

Plasmodesmata: Structure, role in movement of molecules and macromolecules; comparison with gap junction.

Module II:

Cellular organelles: Ultra-structure and function of golgi complex, lysosomes, peroxisomes, endoplasmic reticulum, mitochondria, chloroplast and plant vacuoles.

Cell shape and motility: The cytoskeleton; organization and role of microfilaments, intermediate filaments and microtubules; motor movements, implications in cell division, flagellar & other movements.

Module III:

Nucleus: Ultrastructure, nuclear pores, nucleolus, DNA structure A, B and Z forms, replication in prokaryotic and eukaryotic cells, DNA replication proteins, damage and repair.

Module IV:

Stress biology: Definition and classification of stress.

Biotic stress: Plant defence mechanism (passive and active); HR and SAR; modulation of plant metabolism in response to biotic stress: early and late response; production of ROS, induction of enzymes; PR proteins; R-genes.

Abiotic stress: Effect of water, temperature, salt and light stress on plants; developmental and physiological mechanisms protecting plants against environmental extremes.

Suggested readings

Atherly, A.G., Griton, J.R. and Mc Donald, J. F. 1999. The Science of Genetics. Saunders College Pub. Fort Worth, USA

Buchanan, B.B., Gruissem, W. and Jones, R. L. 2000 Biochemistry and Molecular Biology of Plants. American Soc. Of Plant Physiologists, Maryland, USA.

Bush, H. Rothblum, L. 1982. Vol. X. The Cell Nucleus RDNA part A. Academic Press.

Dc, D. N. 2000 Plant cell vacuoles: An introduction. CSIRO Publication, Collingwood, Australia.

De Robertis, E.D.P. and De Robertis, E.M.F. Cell and Molecular Biology 8Ed. B. I. Waverly Pvt. Ltd., New Delhi.

Jones R, Ougham H, Thomas H and Waaland S 2013 The Molecular life of plants. Wiley-Blackwell Publ., USA

Karp, G. 1999 Cells and Molecular Biology; Concepts and Experiments. John Wiley & Sons, Inc., USA.

Kleinsmith, L.J. and Kish, V.M. 1995 Principles of Cell and Molecular Biology (2nd Edi.)Harper Collins Coll. Publisher, New York, USA.

Krishnamurthy, K.V. 2000 Methods in Cell wall Cyto-chemistry. CRC Press, Boca Raton, Florida

Lodish, H., Berk, A. Zipursky, S. L. Matsudaira, P., Baltimore, D. and Dar nell, J. 2000 Molecular Cell Biology Edi. W.H. Freeman and Co., New York, USA

Russel, P. J. 1998 Genetics (5th Edi.) The Benjamin/ Cummings Publishing Com. Inc., USA

Wolf, S.L. 1993. Molecular and Cellular Biology, Wadsworth Publishing Co., California, USA

Taiz, L. and Zeiger, E. 1998: Plant Physiology. Sinaucr Associates, Inc., Publishers, Massachus, USA

Practicals

1. To study salivary gland chromosomes of Chironomas and Drosophila.
2. To isolate mitochondria and determine the activity of its marker enzyme SDH.
3. To isolate bacterial and plant DNA and quantify them by spectrophotometric method.
4. To demonstrate the semi-permeability of the plasma membrane.
5. To study the activity of Na/K ATPase.
6. To demonstrate different components of cytoskeleton in the suitable material.
7. To perform flagellar staining.
8. Isolation of DNA and preparation of Cot-curve.
9. Demonstration of vital structure and functions of cell
10. To study the activity of PAL in the seedlings challenged with elicitors.
11. To study the induction of antioxidant enzymes in the seedlings challenged with elicitors.
12. To study the effect of water stress on the seedling growth and its chlorophyll content.
13. To study the effect of temperature stress on the seedling growth and its chlorophyll content.
14. To study the effect of salt stress on the seedling growth and its chlorophyll content.

Suggested readings (for laboratory exercises)

Fukui, K. and Nakayama, S. 1996. Plant Chromosomes: Laboratory Methods. CRS Press, Boca Raton, Florida.

Glick, B. R. and Thompson, J.E. 1993. Methods in Plant Molecular Biology and Biotechnology.CRC Press, Boca Raton, Florida USA.

Goswami, H. K. 1986. Practical cytology – Applied Genetics and Biostatistics Himalaya Pub. House, Bombay.

Gunning, B.E.S. and Steer, M.W. 1996. Plant Cell Biology: Structure and Function. Jones and Barlett Publishers, Boston, Massachusetts.

Hall, J.L. and Moore, A.L. 1983.Isolation of Membranes and Organelles from Plant Cells Academic Press, London, U.K.

Harris,N. and Oparka, K.J. 1994. Plant Cell Biology: A Practical Approach. IRL Press, at Oxford University Press, Oxford, U.K.

Sharma, A.K. and Sharma, A. 1999. Plant Chromosomes: Analysis, Manipulation and Engineering. Har Academic Publishers, Australia.

Shaw, C.H. (Ed.), 1988. Plant Molecular Biology: A Practical Approach. IRL Press, Oxford.Techniques, 2nd edition. PAS, IRL Press at Oxford University Press, Oxford.

References: Online journals available on UGC V-SAT programme.

Review Journals:

Annual Review of Plant Physiology and Molecular Biology
Biochemistry and Cell Biology
Cell Death and Differentiation
Cell Motility and the Cytoskeleton
Cellular Physiology and Biochemistry
Current Advances in Plant Sciences
European Journal of Cell Biology Journal of Cell Science
Nature Reviews: Molecular and Cell Biology
Protoplasma-An International Journal of Cell Biology
Trends in Cell Biology
Trends in Plant Sciences

Semester II

2T4 –Core :Angiosperms-I and Ethnobotany

Module I:

Angiosperm Morphology, structural units and floral symmetry, dicot and monocot flower; structure, diversity origin and evolution of stamen, carpels; placentation types and evolution. Floral adaptation to different pollinators

Module II:

Angiosperm Taxonomy: Scope, aims, principles of taxonomy, historical development of plant taxonomy, relative merits and demerits of major systems of classifications. Taxonomic structure: taxonomic hierarchy, concept of taxa, concept of species, concept of genus and family; Taxonomic character: HETEROBATHMY, ANALYTIC versus synthetic character, qualitative versus quantitative characters.

Module III:

Taxonomic evidence: Morphology, anatomy, embryology, palynology, cytology, phytochemistry, genome analysis.

Taxonomic tools: herbarium, floras, monographs, botanical gardens, biochemical and molecular techniques, computers and GIS.

Module IV:

Biosystematics: The population concept phenotypic plasticity, biosystematic categories, methods of biosystematics studies. Numerical taxonomy: principles, aims and objectives, cladistics in taxonomy, polarity of characters, homology, homoplasy, monophyly, polyphyly.

Plant nomenclature: Salient features of ICBN

Ethnobotany: Definition; scope and significance; Sacred groves and their role in conservation.

Practicals

1. To study the floral symmetry in various taxa.
2. To study and work out the differences in dicot and monocot flower.
3. To study the variation in stamens and carpels.
4. To study placentation types in various taxa.
5. To study the floral adaptations for pollination.
6. To study anatomical features of various taxa.
7. To study embryological features of various taxa.
8. To study palynological features of various taxa.
9. To study cytological features of various taxa.

10. To prepare a cladogram on the basis of various morphological features of the species belonging to a genus.

Suggested Readings

Devic, P.H. and Heywood, V. H. 1973. Principles of angiosperms taxonomy. Robert E. Kreiger Pub. Co. Newyork.

Grant, V. 1971. Plant Speciation, Columbia University press, London.

Grant W. F. 1984. Plant Biosystematics. Academic press, London.

Harisson, H.J. 1971. New concept in flowering plant Taxonomy. Hickman educational books Ltd. London.

Hislop-Harisson, J. 1967. Plant Taxonomy. English Language Book Sco. And Edward Arnold Pub. Ltd, UK.

Heywood, V. H. and Moore, D. M. 1984. Current concepts in Plant Taxonomy. Academic Press, London.

Joncs, A. D. and Wibins, A. D. 1971. Variation and adaptation in Plant species Hickman and Co. New York.

Jones, S. B., Jr. and Luchsinger, A. E. 1986. Plant Systematics (gd edition). McGraw -Hill Book Co., New York.

Nordentam, B., El Gazaly, G. and kassas, M. 2000. Plant systematic for 21st century. Portland press. Ltd, London.

Radford, A. E. 1986. Fundamentals of plant systematic. Harper and Raw publication, USA.

Solbrig, O.T. 1970. Principles and methods of plant Sytematics. The Macmillan Co. Publication Co. Inc., USA.

Woodland, D. W. 1991. Contemporary Plant Syatematics, Pentice Hall, New Jersery.

Takhtajan, A. L. 1997. Diversity and classification of Flowering Plants. Columbia University Press, New York.

Stebbins, G. L. 1974. Flowering Plants-evolution Above species Level. Edvard Arnold Ltd, London.

Joncs, A. D.; Wibins, A. D. 1971. Variation and adaptation in Plant species Hickman and Co.

Jones, S. B., Jr. and Luchsinger, A. E. 1986. Plant Systematics (gd edition). McGraw Hill Book Co., New

Semester III
3T1 - Core : Plant Ecology and Conservation Biology

Module I:

Vegetation organization: Concepts of community and continuum, analysis of communities (analytical and synthetic characters): interspecific associations, concept of ecological niche.

Vegetation development: Temporal changes (cyclic and non-cyclic); mechanism of ecological succession (relay floristics and initial floristic composition; facilitation, tolerance and inhibition models).

Community function- Dynamics and succession, laboratory model, trends in succession, climax concept, General introduction to autecology.

Module II:

Ecosystem organization: Structure and functions; primary production (methods of measurement, global pattern, controlling factors); energy dynamics (trophic organization, energy flow pathways, ecological efficiencies); litter fall and decomposition (mechanism, substrate quality and climatic factors); global biogeochemical cycles of C, N, P and S. Nutrient budget in forest and aquatic ecosystem.

Module III:

Ecosystem stability: Concept (resistance and resilience); Ecological perturbations (natural and anthropogenic) and their impact on plants and ecosystems; ecology of plant invasion; environmental impact assessment; ecosystem restoration.

Ecological management: Concepts; sustainable development; sustainability indicators.

Module IV:

IUCN- General account, categories, Commissions, role in conservation; Red Data Book
Protected areas- Sanctuaries, National parks, Biosphere reserves.

Wetlands and Mangroves

Coral Reefs- Types, importance, artificial reefs, conservation measures

Botanical gardens, Seed Banks; *In-vitro* repositories; Cryobanks,

Practicals

Based on Biostatistics

1. Calculate mean, variance, standard deviation and coefficient of variation for comparing two means related to given ecological data.
2. Calculate mean, variance, and to use t-test for comparing two means related to given ecological data.
3. To find out association between important grassland species from the given data using chi-square test.
4. To find out relationship between two ecological variables using correlation analysis.
5. To perform the one-way ANOVA from the given data.

Based on Ecology

1. A trip to the grass land/ forest/ water body to get acquainted with their plant species.
2. Distribution pattern of different plant species determined by Quadrant/Transect/ Point centered Quarter methods.
3. To determine minimum size and number of quadrats required to study grassland.
4. Qualitative parameters of distribution of plant species, Frequency, Density, Basal cover, dominance, Abundance and IVI.

5. To determine diversity indices (Shanon-Weiner, species richness, B-diversity) from given data.
6. To estimate DO content in the eutrophic and oligotrophic water samples by azide modification of Winklers method.
7. To determine gross and net phytoplankton productivity by light and dark bottle method.
8. To estimate chlorophyll content in SO₂ fumigated and unfumigated leaves.
9. Analysis of soils of two different areas i.e. Cropland and forest/ grassland for certain nutrients, CO₃, NO₃, Base defficiency.
10. To study ecological adaptations of the given plants

Suggested readings

1. Ambasht R.S. 1968. Freshwater ecosystem-Manual of Ecology 123-137 (See Misra KC et al 1968)
2. Ambasht R.S. 1966 Conservation Ecology, Abs Proc School on Plant Ecol (Full paper in press Oxford and IBH Calcutta).
3. Ambasht R.S. 1995 A text book of plant ecology Student and co. Varanasi-5
4. Anderson JM Ecology for environmental sciences: biosphere ecosystems and man
5. Billings WB 1964 Plants and the ecosystem Macmillan & co, London.
6. Clements FE 1916 Plant succession, An analysis of the development of vegetation. Carnegie Institute of Washington.
7. Cragg JB 1968 The theory and practice of conservation, IUCN Publ, New Series No. 12, 25-35.
8. Dash MC 1993 Fundamentals of Ecology WB Saunders and co. Philadelphia USA.
9. Deangelis DL Energy flow, nutrient cycling and ecosystem resilience. Ecology 56, 23843.
10. Dwivedi Rama Shankar 1968. The decomposer system manual of ecology See Misra KC et al 1970)
11. Frankel OH, Soule ME, 1981, Conservation and Evolution, Cambridge Univ Press.
12. Grace J 1983, Plant atmosphere relationships. Champman & Hall.
13. Greig Smith P 1983, Quantitative plant ecology, Univ California Press, California.
14. Hutchings MJ (ed) 1988, Plant population biology, Blackwell.
15. Hutchinson GE 1978, An introduction to population ecology. Yale Univ. Press.
16. Kochhar PL 1986 Plant Ecology Ratan prakashan, Mandi, Agra.
17. Krebs GJ 1972 Ecology Harper and Row Publ, New York.
18. Kumar HD 1994 Modern concepts of ecology. Vikas publishing house pvt ltd, New Delhi.
19. May RM (ed) 1981 Theoretical Ecology, Blackwell.
20. Odum EP 1963 Ecology Holt Reinhart and Winston Inc.
21. Odum EP 1983 Basic Ecology, Saunders Publ Philadelphia.
22. Reynolds CS 1984 The ecology of phytoplankton, Cambridge Univ Press
23. Silvertown JW 1982 Introduction to plant population ecology, Longman.
24. Southwick CH 1983 (ed) Global Ecology Sinauer.
25. Whittaker RH 1975 Communities and Ecosystems (2nded) MacMillan, New York.

Semester III

3T2 - Core : Angiosperms-II

Module I

General account, distinguished characters, floral variation and evolution, affinities of:- Magnoliidae, Hamamelidae, Dilleniidae, Rosidae, Asteridae, circumscription as per Cronquist, 1968

Module II

Alismatidae, Commelinidae, Aracidae, Lilidae; Interesting features and systematic position of Cucurbitaceae, Cactaceae, Asteraceae, Amentiferae, Lemnaceae, Palmae, Orchidaceae.

Module III

Probable ancestors of angiosperms, primitive living angiosperms, speciation and extinction, IUCN categories of threat, distribution and global pattern of biodiversity.

Module IV

Biological diversity concept and levels, role of biodiversity in ecosystem functions and stability, Endemism, hotspots and hottest hotspots, invasions and introductions, local plant diversities and its socioeconomic importance.

Practicals

1. Description of specimens from representative, locally available families.
2. Description of a species based on various specimens to study intra specific variation: collective exercise.
3. Description of various species of a genus, location of key characters and preparation keys at generic level.
4. Location of key characters and use of keys at family level.
5. Field trips within and around the campus; compilation of field notes and preparation herbarium sheets of such plants, wild or cultivated as are abundant.
6. Training in using floras herbaria for identification of specimens described in the class.
7. Demonstration of the utility of secondary metabolites in the taxonomy of some appropriate genera.
8. Comparison of different species of a genus and different genera of a family to calculate similarity coefficients and preparation of dendrograms.

Suggested readings

- Devis, P.H. and Heywood, V. H. 1973. Principles of angiosperms taxonomy. Robert E. Kreiger Pub. Co. New York.
- Grant, V. 1971. Plant Speciation, Columbia University press, London.
- Grant W. F. 1984. Plant Biosystematics. Academic press, London.
- Harisson, H.J. 1971. New concept in flowering plant Taxonomy. Hickman educational books Ltd. London.
- Hislop-Harisson, J. 1967. Plant Taxonomy. English Language Book Sco. And Edward Arnold Pub. Ltd, UK.
- Heywood, V. H. and Moore, D. M. 1984. Current concepts in Plant Taxonomy. Academic Press, London.
- Joncs, A. D. and Wibins, A. D. 1971. Variation and adaptation in Plant species Hickman and Co. New York.

- Jones, S. B., Jr. and Luchsinger, A. E. 1986. Plant Systematics (2nd edition). McGraw-Hill Book Co., New York.
- Nordentam, B., El Gazaly, G. and Kassas, M. 2000. Plant systematic for 21st century. Portland press Ltd, London.
- Radford, A. E. 1986. Fundamentals of plant systematic. Harper and Row publication, USA.
- Solbrig, O.T. 1970. Principles and methods of plant Systematics. The Macmillan Co. Publication Co. Inc., USA.
- Woodland, D. W. 1991. Contemporary Plant Systematics, Pentice Hall, New Jersey.
- Takhtajan, A. L. 1997. Diversity and classification of Flowering Plants. Columbia University Press, New York.
- Stebbins, G. L. 1974. Flowering Plants-evolution Above species Level. Edward Arnold Ltd, London.
- Jones, A. D. and Wiggins, A. D. 1971. Variation and adaptation in Plant species Hickman and Co.
- Jones, S. B., Jr. and Luchsinger, A. E. 1986. Plant Systematics (2nd edition). McGraw Hill Book Co., New Delhi.

Semester III

3T3- Core Elective I:(Molecular Biology and Plant Biotechnology- I)

Module I

- DNA replication: DNA replication in prokaryotic organism– Initiation, elongation, and termination, DNA replication in eukaryotes – origin, replication form, replication proteins, Comparative account of DNA replication in prokaryotes and eukaryotes, DNA replication proteins
 - DNA damage and repair: Types of DNA damage, factors for DNA damage, Repair system: Single base change, direct repair, mismatch repair, SOS response.
- Gene expression and regulation: Transcriptional, translational and post-translational regulation

Module II

- Tools of rDNA technology: DNA manipulation enzymes- Nucleases, polymerases, ligases, kinases and phosphatases; methods of gene isolation.
- Molecular probing: Recombinant DNA libraries (gDNA and cDNA, oligonucleotide probes); nucleic acid hybridization (southern, northern, dot-blot and slot-blot); antibodies as probe for proteins (immunoblotting or western blotting, immunoprecipitation, southwestern screening).

Module III

- Splicing of foreign DNA into cloning vector: Vectors for prokaryotes; ligation.
- Introduction of foreign DNA into host cell: Transformation; transfection; transgenesis
- Isolation of genes or protein products from clones: Expression vectors-Characteristics; vectors producing fusion proteins
- Polymerase chain reaction: The basic techniques and its modifications; applications of PCR in molecular biology

Module IV

- Sequence alignment and phylogenetic trees: Pairwise (dot-matrix method, dynamic programming method, Word or k-tuple method) and multiple alignment, Local and global alignment, significance of alignment, phylogeny and phylogenetic trees.

- b. Genomics: Definition; Structural, functional and comparative genomics.
- c. Proteomics: Description of protein structure; classification of proteins on the basis of structure and sequence similarity; prediction of a protein structure.

Suggested readings

- Alberts, Bruce; Johnson Alexander; Lewis, Julian; Raff, Martin; Roberts, Keith; Walter, Peter, C. 2002 Molecular Biology of the Cell, Garland Science, New York and London.
- Baxevanis, A. D. and Ouellate, B. F. F. 2009 Bioinformatics: A Practical Guide to the analysis of genes and proteins. John-Wiley and Sons Publications, New York.
- Baxevanis, A. D., Davison, D. B.; Page, R. D. M.; Petsko, G. A.; Stein, L. D. and Stormo, G. D. 2008 Current Protocols in Bioinformatics
- Bergman, N.H 2007 Comparative Genomics. Humana Press Inc., Part of Springer Science+ Business Media
- Brown, T. A. 1999. Genomes, John Wiley & Sons(Asia) Pvt. Ltd., Singapore
- De Robertis, E.D.P. and De Robertis, E.M.F. Cell and Molecular Biology 8th Ed. B. I. Waverly Pvt. Ltd., New Delhi.
- Glover, D.M. and. Hames, D.B 1995 DNA Cloning : A practical approach, R.L. Press, Oxford.
- Hackett, P. B. Fuchs, J. A. and Messing, J. W. 1988. An Introduction to Recombinant DNA Techniques. Basic Experiments in Gene Manipulation. The Benjamin/cummings Publishing Co., Inc. Menlo Park, California.
- Jolles, O. and Jornvall, H. (eds) 2000. Proteomics in Functional Genomics. Birkhauser Verlag, Basel, Switzerland.
- Karp, G. 1999 Cells and Molecular Biology; Concepts and Experiments. John Wiley & Sons, Inc., USA.
- Lehninger. Principles of biochemistry- Nelson, Cox, 4th Edn., W.H. Freeman and Co., 2005.
- Lewin, B. 2000 Gene VII Oxford Univ. press, New York.
- Lewin, B. 2010 Gene X Oxford Univ. press, New York.
- Lodish, H., Berk, A. Zipursky, S. L. Matsudaira, P., Baltimore, D. and Darnell, J. 2000 Molecular Cell Biology Edn. W.H. Freeman and Co., New York, USA
- Mount W. 2004 Bioinformatics and sequence genome analysis 2nd Edn. CBS Pub. New Delhi
- Old and Primrose, 1994, Principles of gene manipulation. Blackwell Scientific Publ.
- Raymond Schuler and Zielinski, E. 2005, Methods in plants Molecular biology. Acad. Press.
- Russel, P. J. 1998 Genetics (5th Edn.) The Benjamin/ Cummings Publishing Co. Inc., USA
- Sambrook and Russel. 2001. Molecular cloning Vol. 1-3 CSH press.
- Shaw, C.H. 2006, Plant Molecular Biology: A practical approach. Panima Pub. Corp.
- Stryer, Berg, Biochemistry-6th Edition, W. H. Freeman and Co., 2007.
- Voet, D.; Voet, J.; Biochemistry – 3rd Edn. John Wiley and sons Inc., 2004.
- Wilson Keith and Walker John 2005 Principles and techniques of biochemistry and molecular biology, 6th Ed. Cambridge University Press, New York.
- Wolf, S.L. 1993. Molecular and Cellular Biology, Wadsworth Publishing Co., California, USA

Practicals

Group A

1. To detect the damage caused by mutagens to the DNA.
2. To detect molecular polymorphism in different species using a suitable technique.
3. To demonstrate the presence of a particular polypeptide by Western blotting.
4. To design PCR primers to isolate the given gene for cloning it in the given vector.
5. To amplify and sequence the nrDNA by PCR
6. To find the sequences of a given protein in the protein database

7. To work out the sequence from given autoradiogram and to identify it from GeneBank by BLAST method.
8. To download the DNA sequences from databases and generate pairwise and multiple sequence alignment.
9. To download the protein sequences from databases and generate pairwise and multiple sequence alignment.
10. To generate phylogenetic tree using given sequences.
11. To predict a protein from given sequence by using online tools from NCBI.

Group B

12. To demonstrate *Agrobacterium tumefaciens* mediated gene transfer in a suitable plant.
13. To perform ELISA testing of Bt gene in cotton.
14. To raise the suspension culture using a callus and plot the growth curve.
15. To induce the secondary metabolite synthesis in suspension culture.
16. To isolate the secondary metabolites from suitable plant material by gel filtration method.
17. To purify the plant metabolite/ protein by column chromatography.
18. To demonstrate the use of molecular markers to detect polymorphism in different varieties of plants/strains of microbes.
19. To isolate and develop the protein profile of different plant species by SDS-PAGE.
20. To demonstrate bacterial transformation and selection of transformed cells.
21. To perform DNA ligation and analysis of ligated DNA on agarose gel.
22. To study of expression of inducible genes at biochemical level.
23. To demonstrate Organogenesis using appropriate explants.
24. To demonstrate somatic embryogenesis using appropriate explants and prepare artificial seeds.
25. To demonstrate preparation of artificial seeds.
26. To demonstrate the anther culture.
27. To study the effect of heavy metals on the growth of plants.
28. To screen the hyperaccumulator plants for a given heavy metal.

Suggested readings (for laboratory exercises)

Baxevanis, A. D. and Ouellette, B. F. F. 2009 Bioinformatics: A Practical Guide to the analysis of genes and proteins. John-Wiley and Sons Publications, New York.

Baxevanis, A. D., Davison, D. B.; Page, R. D. M.; Petsko, G. A.; Stein, L. D. and Stormo, G. D. 2008 Current Protocols in Bioinformatics. McEntyre, J.; Ostell, J., editors Bethesda (MD) The NCBI Handbook: National Library of Medicine (US), NCBI; 2002-2005

Sambrook and Russell. 2001. Molecular cloning Vol. 1-3 CSH press.

Tools & updated literature available at www.ncbi.com

References: Online journals available on UGC V-SAT programme.

Semester III
3T3 - Core Elective I :(Mycology and Plant Pathology - I)

Module I: General Microbiology

Bacteria- Morphology, size, shape, structure, Characters of Eubacteria, Actinomycetes, Archaeobacteria, Bacterial nutrition, reproduction.

Viruses- General Characteristics, structure, classification (LHI System), replication (lytic cycle & lysogeny)

Rickettsia- General Characters.

Fungal diversity in different ecosystems, effect of environment on fungal growth and behaviour.

Module II: Mycorrhiza

1. Kinds of mycorrhizae. Ectotrophic and endotrophic mycorrhizae, their morphology and anatomy. V A-mycorrhiza. Mycorrhiza in plant growth promotion, mycorrhiza in plant disease control.

2. Rhizosphere and phyllosphere -General concept and importance.

3. Medical Mycology-Dermatophytic fungi -Knowledge of common dermatophytes and human diseases caused by them viz. *Tinea pedis*, *Tinea capitis*, *Tinea barbae*. *Tinea corporis* and *Tinea manuum*; Aspergillosis, fungi allergic to human beings.

Module III: Production of Metabolites by Fungi

A) Industrial Fungal Metabolites:

i) Antibiotics -Penicillin, Cephalosporin, Griseofulvin, Industrial production of Penicillin

ii) Enzymes -. Amylase, proteases, Lipases, Pectinases, Cellular and xylanases.

iii) Organic acids -Citric acid, Gluconic acid, lactic acid, kojic acid, Itaconic acid.

B) Non Industrial Fungal Metabolites:

i) Phytoalexins, ii) Mycotoxins

Module IV: Fungi as welfare to human beings

i) Fungi in food processing: soybean products, cheese, fermented milk, other fermented foods.

ii) Fungal metabolites – General account of production and application: Primary metabolites (vitamins, proteins), Secondary metabolites (antibiotics, pigments, alkaloids)

iv) Fungi as food -edible mushrooms, methods of their cultivation

v) Concept of biodeterioration and Biodegradation

a) Biodeterioration of non-cellulosic materials (leather, plastics, hydrocarbons, pesticides)

b) Biodeterioration of cellulosic materials.

c) Role of microorganisms in Biodegradation of organic wastes. Factors affecting the process of Biodegradation.

Suggested readings

1. Agrios, G.N. (1980) Plant Pathology, Academic Press, INC, New York.

2. Ainsworth, G.C. and A.S. Sussman (eds). The Fungi, An advance Treatise Vol.I, II, III & IV Academic Press, New York.

3. Alexopoulos, C.J. (1962). Introductory Mycology John Wiley Eastern Pvt.Ltd.

4. Alexopoulos, C.J. and Mims C.W. (1979). Introductory Mycology 3rd Edition, John Wiley and Sons, Inc. Wiley, New York.

5. Alexopoulos, C.J., Mims and Black well (1996) 4th ed. John Wiley and Sons, Inc. Wiley, New York

6. Aneja, K.R. (1993) Experimental in Microbiology, Plant Pathology & Tissue Culture, Wiswa Prakashan, New Delhi.

7. Bessey, E.A. (1950) Morphology and Taxonomy of Fungi. The Blakiston co. Philadelphia.
8. Bilgrami, K.S. and H.C.Dube (1985) A text Book of Modern Plant Pathology, Vikas Publication House, New Delhi.
9. Barnett, J.H. (1968) Fundamentals of Mycology. The English Language Book Society and Edward Arnold Publication, Limited.
10. Dube, R.C. and D.K.Maheshwari (1999) A.Text Book of microbiology, S.Chand & Co. Ltd.
11. Dube, R.C. and D.K.Maheshwari (2000) Practical Microbiology -S.Chand & Co. Ltd.
12. Gupta, V.K. and M.K.Behl (1994) Indian Plant Viruses and Mycoplasma Kalyani Publishers, 1/1, Rejinder Nagar, Ludhiana.
13. Jha, D.K. (1993) A Text Book of Seed Pathology, Vikas Publication House.
14. Mehrotra, R.S. (1989) Plant Pathology, Tata McGraw Hill.
15. Mehrotra, R.S. and K.R.Aneja (1998) An Introduction to Mycology, New Age Intermediate Press.
16. Pelzer, M.J. , Jr.Cahn, E.C.S. and N.R.Krieg (1993) Microbiology, Tata McGraw Hill.
17. Preece and Dickeson. Ecology of leaf surface microorganism Academic Press, New York.
18. Rangaswamy, G. and A.Mahadevan (1999) Diseases of Crop Plant in India, Prentice Hall of India.
19. Raychoudhari, S.P. and Nariani, T.K. (1977) Virus and Mycoplasma Diseases of Plant in India, Oxford and IBH Publication Co.
20. Schlegel, H.G. (1996) General Microbiology, 7th Edition, Cambridge University Press.
21. Snowdon, A.L. (1991) A colour Atlas of Post harvest diseases & disorders of fruits & vegetables Vol.I & II Wolfe Scientific, London.
22. Sunder Rajan, S. (2001) Tools and Techniques of Microbiology, Anmol Publ.New Delhi.
23. Thind, T.S. (1998) Diseases of field crops and their management, National Agricultural Technology, Information Centre, Ludhiana.
24. Vaidya, J.G. (1995) Biology of the fungi, Satyajeet Prakashan, Pune.
25. Walker, J.G. (1952) Diseases of Vegetables Crops. McGraw Hill, New York.
26. Walker, J.C. (1968) Plant Pathology, McGraw Hill, New York.
27. Eggins, H.O.W. and Allsop (1975) The Filamentous Fungi Vol. I Industrial Mycology (Biodeterioration and Biodegradation by Fungi) Eds. J.E. Smith and D.R. Berry Edward Arnold, London.
28. Emmons, C. W., C. H. Bin ford, J.P. Utz and Know Chung (1977) Medical Mycology, Lea and Febigo, Philadelphia.
29. Holliday, P. Fungus disease of tropical plants (1980), Cambridge University Press, Cambridge.

On line Journals available on UGC -VSAT

Practicals

1. Principles & working of tools, equipments and other requirements in the Mycology & Plant Pathology laboratory.
2. Micrometry and measurement of organisms.
3. Sterilization Processes viz. moist heat, dry heat, chemical and radiation.
4. Drawing of Camera Lucida diagrams and knowledge of computer based photomicrography and image processing
5. Preparation of different cultural media for cultivation of Fungi and Bacteria.
6. Monitoring and analysis of Aeromycoflora.
7. Isolation & identification of Phyllosphere mycoflora.
8. Demonstrate antifungal activities of different antibiotics and leaf, flower and root extract.
9. Study of toxicity of fungi in relation to seed germination, and seedling abnormality.
10. Cultivation of Mushrooms.

11. Demonstration on biodegradation of organic waste.
12. Isolation of Soil fungi by soil plate (War cup) and serial dilution (Walksman) method.
13. Isolation and identification of Rizosphere mycoflora.
14. Isolation of external and internal seed borne mycoflora by blotter and Agar Plate method. Cereals, pulses, oil seeds, fruit seeds.
15. Demonstration of Koch's Postulate.
16. Calculation of spore count using haemocytometer.
17. Qualitative estimation of enzymes – cellulases, amylases.
18. Estimation of sugars, proteins and aminoacids in fungal mycelium and culture filtrate.
19. Study of mycorrhiza (VAM)
20. Monographic study of locally available plant diseases caused by fungi (atleast 10).
21. Study of locally available crop plant diseases caused by Bacteria (Five)
22. Study of locally available plant diseases caused by viruses & Phytoplasma (Five)
23. Demonstration of morphological & physiological changes in disease plants.
24. Preparation and presentation of herbarium of pathological specimens available in the region (Atleast 15)
25. Field visit to different localities Visit to Agriculture University, Plant Pathological research centers

Semester III

3T3- Core Elective I: (Reproductive Biology of Angiosperms - I)

Module I

General: Need for reproductive system as experimental material, Interdisciplinary approaches: genetic and molecular perspective,

Anther: Structure, anther wall; endothecium, middle layer, tapetum-Structure, typesstructure-function relationship, role of tapetum, microsporogenesis-sporogenous cells cytoplasmic reorganization during sporogenesis (Ultrastructural changes), molecular biology of meiosis, DNA and RNA synthesis, Protein synthesis, meiosis specific genes. Pollen tetrad development, pollen wall proteins, adaptive significance of pollen wall.

Module II

Male gametophyte development: formation of vegetative and generative cells, differential behaviour of sperms, gene expression during pollen development.

Pollen: Physiological and biochemical aspects, pollen storage, viability, causes for loss of viability. Pollen abortion and male sterility: structural, developmental and functional aspects of male sterility environmental factors, role of mitochondrial genome in male sterility, gametocides.

Module III

Pistil: Carpel determination, ovule and its structural details.

Megasporogenesis: Meiosis, functional megaspores, organization of female gametophyte structure of the embryo sac, egg, synergid-ultrastructure, role central cell, antipodal cell, haustoria, cytoskeleton of the embryo sac, enzymatic isolation of embryo sac, types of embryo sac, nutrition of embryo sac.

Module IV

Pollination: pollination mechanism, biotic and abiotic pollination, floral attractants and rewards,

Pollen-pistil interaction: The stigma-Types and structure, stigmatic exudates, style-transmitting tissue, canal cell, post pollination events (stigma receptivity, pollen adhesion, pollen hydration, pollen germination and pollen tube growth, biochemistry of pollen germination, RNA and protein metabolism during pollen tube, calcium gradient in the pollen tube (Chemotropism) pollen allelopathy.

Incompatibility: General concept, self incompatibility (Intraspecific type) heteromorphic, homomorphic types, mechanism of self compatibility, importance of self compatibility, methods of overcoming self incompatibility, Parasexual hybridization,

Suggested readings

1. Asker S. 1979, Progress in apomixis research. *Hereditas* 91, 231-240.
2. Barnier, G. 1986, The flowering process as an example of plastic development. *Soc. Expt. Biol.* 40: 257-286.
3. Barth, F.G. 1991, insects and flowers, Princeton Univ. Press. Princeton.
4. Battaglia, E. 1963. Apomixis In recent advances in the embryology of angiosperms (ed P. Maheshwari), pp-264, Intt. Soc. Plant Morphologists, Univ. Delhi.
5. Bhandari N. N. 1984, The microsporangium in embryology of angiosperms (ed B.M. Johri) Springer-Verlag, Berlin, pp. 53-121.
6. Bhandari N.N., M. Bhargava and P. Chitrlekha 1986, Cellularization of free nuclear endosperm of *Papaver somniferum* L. *Phytomorphology*, 36, 357-366.
7. Bhojwani S.S. and M.K. Rajdan 1983, Plant tissue culture Theory and Practice Elsevier, Amsterdam.
8. Boesewinkel F.D. and Boman F. 1984, The seed structure in embryology of angiosperms (ed B.M.Johri), Springer-Verlag, Berlin, pp. 567-610.
9. Bouman F. 1984 The ovule in embryology of angiosperms (ed B.M.Johri), Springer-Verlag, Berlin, pp. 123-157.
10. Cartson P.S., Smith N.H., Dearing R.D. (1972) Parasexual interspecific plant hybridization. *Proc. Nat. Acad. Sci. USA*, 69, 2292-2294.
11. Cartson P.S. (1973) The use of protoplasts of genetic research. *Proc. Nat. Acad. Sci. USA*, 70, 598-602.
12. Chitrlekha P. and N.N. Bhandari 1991, Post fertilization development of antipodal cells in *Ranunculus scferatus*. *Phytomorphology* 41, 200-212.
13. Ciampolini F.M., Nepi and E. Pacini 1993, tapetum development in *Cucurbita pepo* (Cucurbitaceae) *Pt. Syst. Evol. (Suppl)* 7-13-22.
14. Cocking E.C. 1960, A method for the isolation of plant protoplasts and vacuoles. *Nature (London)* 187-927-929.
15. Cocking E.C. 1970, Virus uptake, cell wall regeneration and virus multiplication in isolated plant protoplasts. *Int. Rev. Cytol* 28-89-124.

Practicals

- 1) Study from the permanent preparations.
 - a) Development and structures of anther pollen.
 - b) Structure of ovule, types, megasporogenesis, embryo sac types.
 - c) Development of endosperm, types.
 - d) Structure and development of embryo-types
 - e) Pericarp and seed coat structure from sections and macerations.
 - f) Sketching of ovular structure, embryo sac, anther wall, embryo with the help of camera lucida.

- 2) Techniques, Familiarity with phase contrast, polarizing, fluorescence and electron microscopy, wholemounts, dissection and macerations, permanent double stained microtome sections, photo microscopy.
- 3) Preparation of dissected wholemounts of endothecium, tapetum, endosperm and embryo, squash preparations of tapetum, microspore mother cells, dyads, tetrads pollinia and massulae. Study of mitosis and meiosis and identification of various stages.
- 4) Study of different pollen using acetolysed and non acetolysed pollen, preparation of permanent slides for morphological study. (polarity, symmetry, shape, size, aperture, sporoderm stratification: minimum 15 slides to prepare).
- 5) Interpretation of electron micrographs (SEM, TEM) of pollen.
- 6) Short term exercises on pollen production, viability and their percentage of germination. Rate of growth of germ tube to be studied in a given period.
- 7) Viability of seed through germination, biochemical and excised embryo methods.
- 8) Cytology of pollen inhibition in self and interspecific incompatibility, application of some technique to overcome incompatibility.
- 9) Experiments on intra-ovarian pollination.
- 10) Experiments on plant tissue culture. Technique-washing. Sterilization, preparation of media, storage of media, inoculation, callus initiation, proliferation.
- 11) Responses of calli to stress condition viz. temp, (low, high), moisture, salinity.
- 12) Induction of androgenesis through anther culture.
- 13) Physiology of embryo development, using electrophoretic and histochemical methods embryo culture.
- 14) Somatic embryogenesis
- 15) Protoplast culture.

Semester III

3T3 - Core Elective I: (Plant Physiology - I)

Module:-I

Plant Growth and Development: - Growth, Differentiation and development. Control of growth and development, genetic control of development, hormonal control of development. Pattern of growth and development, Plant growth Kinetics- Growth through time, Plant organs- How they grow? Morphogenesis.

Nitrogen: Importance of nitrogen for growth and development, nitrogen cycle, biological nitrogen fixation, symbiotic nitrogen fixation in legumes

Module-II

Growth Regulators (Plant Hormones): -Biosynthesis, Storage, breakdown and transport, physiological effects and movement of action., ABA, ethylene And nontraditional growth hormones, Jasmonate, Brassinosteroids, oligosaccharins, polyamines, salicylate, nitric oxide, commercial application of plant growth regulators,

A brief idea about role of plant growth retardants: - a) CCC b) maleic hydrazide c) Trizoles d) TIBA

Module-III

Seed physiology:-

Structure of monocot and dicot seed

Latent life -Seed dormancy: Importance and types of dormancy, overcoming seed dormancy, bud dormancy. Factors responsible for dormancy, mechanism of dormancy, methods of breaking the seed dormancy.

Germination of seed: types of germination, chemical Changes during germination, mobilization of reserve Food during germination, hormonal Control seed Germination

Post Harvest Physiology: Ripening of fruit and its regulation, metabolism of leafy vegetables during storage.

Seed development: Biochemical changes during development of seeds.

Module-IV

Stress physiology: Response of plants to biotic (pathogen and insect) and abiotic Stress (water, temperature and salt)

a) **Biotic Stress:** - mechanism of resistance to biotic stress (HR, SAR) and tolerance to abiotic stress

b) **Abiotic Stress:-**

Water stress: - causes of water stress, drought effect On physiological processes in plants, various mechanism of drought resistance in plants.

Flooding stress: - nature of water logging stress. Effect of flooding on physiological processes in plants. Mechanism of water logging tolerance

Salt stress :- definition of saline soil, physiological responses of plants to salinity stress, halophytes and glycophytes mechanism of salinity tolerance in higher plants, genetic engineering for salt tolerance.

Thermal stresses: - Effect of high and low temperatures on plant metabolism, mechanism of high and low temperatures tolerance, cold hardening, role of HSP.

Oxidative stress: - Generation of reactive oxygen species, effect of ROS on metabolism, ROX detoxification mechanisms in plants.

Suggested Readings (For theory):

Asana, R.D. and Sarin M.N. (1968): Crop Physiology in India IARI Publ.

Abdelhamid Elaissari, (2008). Colloidal Nanoparticles in Biotechnology, John Wiley

Apps *et al.*, (1992). Biochemistry, ELBS.

Atwill, B.J. Kriedemann, P.E. and Jumbull, C.G.N. (eds). 1999. Plants in Action : Adaption in Nature Performance, in Cultivation, MacMillan Education. Sydney, Australia.

Buchanan, B. B., Gruissem, W. and Jones, R.L. 1989. Biochemistry and Molecular Biology of plants. American Society of Plant Physiologists, Maryland, USA.

Bewley. J.D. and Black, M. 1994. Seeds: Physiology of Development and Germination, Plenum Press. New York.

Charles PP and Frank JO, (2006). Introduction to Nanotechnology, Wiley India Ed.

Cherry, J. H. 1989. Environmental stresses in plants. biochemical and physiological mechanisms.

Conn E.E, Stumpf, Bruening G, Doi RH. (2005). Outlines of Biochemistry 5/Ed, Wiley & Sons Pvt. Ltd.

Caret *et al.*, (1993). Inorganic, Organic and Biological Chemistry, WMC Brown Pub. USA.

Dey, P. M. And Harborne, J. B. 2000: Plant Biochemistry, Harcourt Asia PTE Ltd. A Harcourt Publishers International Company, 583 Orchard Road 09-01 Forum Singapore-238884.

Dennis, D.T., Turpin, D. H., Lefebvre, D.D. and Layzell, D.B. (eds). 1997. Plant Metabolism (2nd Ed.) Longman, Essex, England.

Evans, L.T. 1972. Crop physiology

Fageria, N. K. 1992. Maximizing crop yield.

Fertilizer association of India (1974): Fertilizer handbook of Usage.

Fitter, A. H. and Hay, R. K. M. S. (1987): Environmental Plant Physiology.

Gupta, U. S. (1972): Crop Physiology.

Gupta, I. S. (1986): Physiological aspects of dryland farming.

Gupta, U. S. (1975): Physiological aspects of dryland farming.

Gaiston, A.W.1989. Life Processes in Plants. Scientific American Library, Springer-Verlag, New York, USA.

Hans-Walter Heldt (2004) Plant Biochemistry . Elsevier Academic Press, 200 Wheeler Road, Burlington, MA 01803, USA, 525 B Street, Suite 1900, San Diego, California 92101-4495,USA

Hooykass P.J.J., Hall, M. A. and Libbenga, K.R.(eds).1999. Biochemistry and molecular Biology of plant Horm. Elsevier, Amsterdam, The Netherlands.

Hopkins, W.G. 1995. Introduction to Plant Physiology. John Wiley & Sons, Inc., New York,USA.

Hale, M.C. and Orcutt, D.M. (1987): The Physiology of Plants Under Stress. ICARhandbook of Fertilizers.

Jain J.L. *et al.*, (2008). Fundamentals of Biochemistry, Chand ,New Delhi

Kozlowski, T. T. (1984): Flooding and Plant Growth. 11. Levitt, J. (1969, 1980): Responses of Plants to Environmental Stress.

Lodish, H., Berk, A., Zipursky S.L., Matsudaira, P., Baltimore, D and Darnell, J. 2000. Molecular Cell Biology (4thed). W. H. Freeman and Company. New York ,USA.

Moore, T.C. 1989. Biochemistry and Physiology of Plant Hormones (2nded). Springer- Verlag, New York, USA.

Mansfield, C.A. (1976): Effect of air pollutant on plants.

Marschner, H. W. (1986): Mineral nutrition of Higher Plants.

McLaren, J.S. (1985): Chemical manipulation of crop growth and Development.

Mehrotra, R.S. (1980): Plant Pathology.

Mahadevan ,A and Sridhar R.(1986) Methods in Physiological plant Pathology, Sivakami Publications, Madras

Nobel, P.S.1999. Physicochemical and Environmental Plant Physiology (2nd ed). Academic Press, Diego, USA.

Nelson D.L, Cox M.M.(2005). Lehninger Principle of Biochemistry, W.H. freeman and Company, New York

Nickell, L.G. (1986): Plant growth regulators in Agriculture.

Pessarkli, M. (2004): Handbook of Plant and Crop Physiology, Marcel Dekkar Inc. NY.

Pessarkli, M. (2005): Handbook of Photosynthesis.

Pradeep T. (2007). NANO : The Essentials – Understanding Nanoscience andNanotechnology, TATA McGraw – Hill Education.

Paleg, L.G. and Aspinal, D.(1982): The Physiology and Biochemistry of Drought resistant in Plants.

Pojakoff Mayber A. and Gale, J. (1975): Plants in saline environment.

Rawn, D. (1989).Biochemistry, Neil Patterson.

Ranjan, purohit, Prasad 2003: Plant Hormones Action and Application, Agrobios(India), agro house, behind Nasrani cinema Chopasani Road, Jodhpur -342002

Rice, E. L. (1982): Allelopathy (Physiological Ecology).

Raven, P.H., Evert, R.F. and Eichhorn, S. 1992. Biology of Plants (5th edition).Worth,New York.

Rastogi , S.C (2003). Outlines of Biochemistry , CBS Publishers &Distributors , NewDelhi

Salisbury, P.B. and Ross, C.W. 1992. Plant Physiology (4th edition).WadsworthPublishing, Belmont, California.

Steeves, T.A. and Sussex, I.M., 1989.Patterns in Plant Development (2nd edition). Cambridge University Press, Cambridge.

Stryer, L., (1988). Biochemistry, WH Freeman & Co., NY.

Satyanaryana U, Chakrapaani U, (2006). Biochemistry, Books and Allied (P)Ltd.

Sharma, S. Raghavan, V. 1999. *Developmental Biology of Flowering Plants*. Springer-Verlag, New York.

Sinha S.K., Sane P.V., Bhargava S.C. and Agarwal P.K. (1990): *Proceeding of International Congress of Plant Physiology* Vol. I & II.

Salisbury, F.B. and Ross, C.W. 1992: *Plant Physiology* (4th ed). Wadsworth Publishing Co., California, USA.

Singhal G.S., Renger, G., Sopory, S.K., Irrgang, K.D. and Govindjee. 1999: *Concepts in Photobiology: Photosynthesis and Photomorphogenesis*. Narosa Publishing House, New Delhi.

Turner, N. C. and Cramer, P.J. (1980): *Adaptation of plants to water and high temperature stress*.

Taiz, L. and Zeiger, E. 1998: *Plant Physiology*. Sinauer Associates, Inc., Publishers, Massachusetts, USA.

Thomas, B. and Vince-Prue, D. 1997: *Photoperiodism in Plants* (2nd ed). Academic Press, San Diego, USA.

Upeke, L. K. (1982): *Tropical tree crops*.

Westhoff, P. 1998: *Molecular Plant Development: From gene to plant*. Oxford University Press, Oxford, UK.

Zuley G.L., (1998). *Biochemistry*, Wm.C. Brown Publishers USA.

Journals

- Annual reviews of Plant Physiology and Molecular Biology.
- Indian Journal of Plant Physiology.
- Journal of Experimental Botany.

Suggested Laboratory Exercises

1. Estimation of phenols from given plant material.
2. Estimation of proline from plant tissues under different environmental and physiological conditions.
3. Study the effects of red and infrared radiation on seed germination as affected.
4. Determination of gibberellic acid by half seed (cereal) method.
5. Demonstration of effects of auxin on abscission.
6. Demonstration of effects of cytokinin on senescence.
7. Demonstration of effects of abscission acid on stomatal regulation.
8. Preparation of cytoplasmic and chloroplastic LPC.
9. Estimation of Vitamin 'C' from suitable plant material.
10. Estimation of alkaloids from medicinal plants.
11. Study of changes in starch / protein content during seed development.
12. Study of lipid accumulation during development of oil seeds.
13. Study of effect of PEG induced water stress on seed germination.
14. Study the effect of ZnSO₄ (800ppm) solution on (paddy) seed germination
15. study the physical and chemical methods for breaking the seed dormancy .

Suggested Readings (for laboratory exercises):

Bajracharya, D. 1999. *Experiments in Plant Physiology: A Laboratory Manual*. Narosa Publishing House, New Delhi.

Cooper, T.G. 1977. *Tools in Biochemistry*. John Wiley, New York, USA.

Copeland, R.A. 1996. *Enzymes: A Practical Introduction to Structure, Mechanism and Data Analysis*. VCH Publishers, New York.

Dennison C. 1999. *A guide to Protein Isolation*. Kluwer Academic Publishers, Dordrecht, The Netherlands.

- Devi, P. 2000. Principles and Methods of Plant Molecular Biology, Biochemistry and Genetics. Agrobios, Jodhpur, India.
- Dryer, R. L. and Lata, G. F. 1989. Experimental Biochemistry. Oxford University Press, New York.
- Hames, B.D.(Ed.).1998. Gel Electrophoresis of Proteins: A Practical Approach, 8th edition. PAS, Oxford University Press, Oxford, UK.
- Harborne, T.C. 1981. Phytochemical Methods: A Guide to Modern Techniques of Plants Analysis. Chapman & Hall, London.
- Moore, T.C. 1974. Research Experiences in Plant Physiology: A Laboratory Manual. Springer-Verlag, Berlin.
- Ninfa, A. J. and Ballou, D. P. 1998. Fundamental Laboratory Approaches for Biochemistry and Biotechnology. Fitzgerald Science Press, Inc., Maryland, USA.
- Plummer, D.F. 1988. An Introduction to Practical Biochemistry. Tata McGraw-Hill Publishing Co. Ltd., New Delhi.
- Scott, R.P.W. 1995. Techniques and Practice of Chromatography. Marcel Dekker, Inc., New York.
- Wilson, K. and Goulding, K.H.(Eds), 1986. A Biologists Guide to Principles and Techniques of Practical Biochemistry. Edward Arnold, London, UK.
- Wilson, K. and Walker, J. 1994. Practical Biochemistry: Principles and Techniques, 4th edition. Cambridge University Press, Cambridge, UK.
- Sadasivam and Manikum: Biochemical Methods, New Age International (p) Limited Publishers 4835/24, Ansari Road, Daryaganj, New Delhi- 110002

Semester III **3T3 - Core Elective I:(Palynology - I)**

Module I

General aspects of Palynology: -Historical background, Definition, basic concepts, scope, inter-relationship with other branches of Botany, Applications, Indian work on Palynology, Palynological centres in India.

Microsporogenesis : Stamen initiation, anther differentiation- anther initiation, anther wall, Tapetum, structure and functions, its role in pollen development, Functions of callose wall, pollen/microspore and wall development, production and deposition of sporopollenin.

Pistil : Structure and function of stigma and style, stigma receptivity and its importance.

Module II

Pollination Biology -Origin of pollination biology/anthecology, Spore and pollen dispersal in lower plants and gymnosperms, Pollination in angiosperms- types of pollination, floral adaptation to different pollinators(mode, style) flowers pollinated biotically (Hymenoptera, Diptera, Coleoptera, Lepidoptera, birds, bats) and abiotically (wind, water), pollination-plant interactions, special devices associated with pollinator attraction - pollen, nectar, Elaiophores, resin glands, osmophores, floral scent and perfume flowers.

Palaeopalynology: - Palynomorphs, their preservation in diverse lithic types, techniques involved in the recovery and concentration of spores and pollen from clays, shales, coals and lignites. Maceration techniques, Application of Palynology in relation to oil and coal exploration. Role of spores and pollen in stratigraphy, index spores.

Module III

Phylogeny of Pollen and spores, Systematic palynology-monocotyledoneae and dicotyledoneae, evolutionary trends among pollen grains based on palynotaxonomical works, Palynology of spores / pollen- Algae, Fungi, Bryophytes, Pteridophytes and pollen types of Gymnosperms. Pollen morphology of Angiosperms.: Introduction- Pollen units, polarity, symmetry, Shape, size, Apertures size, shape of the pollen grain, sporoderm stratification, Apertures-NPC System of classification, Apertural types, Exine ornamentation, LO analysis, evolutionary trends in exine structure, trends of evolution in apertural pattern, Techniques for the preparation of pollen slides, Light and scanning electron microscopic studies of pollen, significance of SEM and TEM studies.

Module IV

Melittopalynology- Pollen analysis of honey-methods, qualitative and quantitative, social organization of honey bees, foraging behavior, geographical and floral origin of honey, its chemical analysis, adulteration of honeys, physical characteristics of honey, deterioration of honey, heavy metal contamination in honey, honey as environmental monitors, unifloral and multifloral honey, Applied Palynology with special reference to Agriculture and Horticulture - Bees as pollinators, role of apiaries in crop production. Use of honey in medicine, cosmetics, confectionary and other applications, Pollen loads, analysis, Bee pollen, chemical composition, utility, and its role in curing various human ailments.

Suggested Readings

1. Afzelius, B.M. 1956 Electron-microscope investigation into exine stratification *Grana Palynologica* (N.S.) 1:2,
2. Agashe S. N. – Paleobotany (1997) – Plants of the past their evolution paleoenvironment and applications in exploration of Fossil.
3. Agashe S. N. – Palynology and its Applications – Oxford and IBH Publishing Co.Pvt. Ltd. New Delhi.
4. Alexander M.P. (1969). Differential staining of aborted and non-aborted pollen *Stain Technol* 44:117-122.
5. Alexander, M.P. (1987). A method for staining pollen tubes in pistil. *Stain Technol* 62, 107-112.
6. Alexander, M.P., Ganeshan S. (1990). An improved cellophane method for *in vitro* germination of recalcitrant pollen. *Stain Technol* 64:225-227. *Archaeology, Rev. Palaeobot. Palynol* 21:171-185,
7. Baker, H.G. 1954. Aperture membranes in Studies of Pollen Morphology and Taxonomy. *New phytologist*, 54(3),
8. Banerjee, U.C. 1965, et al. Exine plasticity during pollen grain maturation. *J. palynol.*:70-89,
9. Banerjee, U.C. 1967. Ultrastructure of the tapetal membranes in grasses. *Grana palynologia*: 7,2-3,
10. Bhattacharya K., Majumdar M. and Gupta Bhattacharya S. (2006). A text book of Palynology. New Central Book Agency(P) Ltd., Kolkata
11. Bhojwani, S .S. and S.P. Bhatnagar. 1978. The Embryology of Angiosperms. Vikas Publishing House, New Delhi,
12. Bir Bahadur 1998. Nectary biology. Datt sons publications, Nagpur Bombay,
13. Brooks. J. and G. Sha'w. 1978. Sporopollenin: A review of its chemistry, palaeochemistry and Geochemistry. *Grana*. 17(2) : 91-98.
14. Caulton Eric, Agashe S. N. - Pollen and Spores applications with special emphasis on Aerobiology and Allergy

15. Chowdhary, J.B. and T.M. Varghese. 1968. Pollen sterility in crop plants- A review *Palyn. Bull.* IV (2).
16. Colombo P.M., Lueehin F., Colombo B. (1977). On the control of the population effect on in vitro assays of pollen germination. *J Exp. Bot.* 28:425-438.
17. Cresti, M., Gori P., Pacini E. (eds.) (1988) Sexual reproduction in higher plants. Springer, Berlin Heidelberg New York Tokyo.
18. Cronquist, A. 1968. The evolution and classification of flowering plants, Nelson, London
19. Dafni Amots, Hesser Michel, Paeini Ettore – Pollen and Pollination- Springer Wien New York
20. Davis. P.H. and V.H. Heywood. 1963. Principles of Angiosperm Taxonomy. Oliver and Boyd, London,
21. Dumas C, Knox R.B. (1983). Callose and determination of pistil viability and incompatibility. *Theor Appl. Genet* 67: 1 -10.
22. Echlin, P. Pollen. 1968. *Scientific American* 218(4), 23. EI-Gazzar and M.K. Hamza. 1973. Morphology of the twin Pollinia of Asclepiadaceae. *Pollen et spores* XV (3-4)
24. Erdtman, G. (1956) "Lo-analysis" and "Welcker's rule". *Sven Bot. Tidskr.* 50:1-7.
25. Erdtman, G. 1945. Pollen Morphology and Plant Taxonomy IV Labiatae, Verbenaceae, Avicenniaceae. *Svensk Botanisk Tidskrift.* 39(3),
26. Erdtman, G. (1966). Pollen morphology and plant taxonomy angiosperms hafner. New York.
27. Erdtman, G. (1969). Handbook of Palynology. Hafner, New York
28. Erdtman, G. 1943. An Introduction to Pollen Analysis. *Chronica Botanica Co.* Waltham, Mass. pp. 239,
29. Erdtman, G. 1952. Pollen Morphology and Plant Taxonomy (An Introduction to Palynology-1, Angiosperms). Aimqvist, and Wicksell, Stockholm,
30. Erdtman, G. 1956. Current Trends in Palynological Research *Work Grana Palynologica* (N.S.) 1:2,
31. Erdtman, G. 1960. The Acetolysis method revised description *Su. Bot. Tidskr.* 54(4).
32. Erdtman, G. 1964. Palynology. In: W.B. Turrill (Editor) *Vistas in Botany.* Macmillan Co., New York, Vol. 4:23-54,
33. Erdtman. G. 1945. Pollen Morphology and Plant Taxonomy V on the occurrence of tetrads and dyads. *Su. Bot. Tidskr.* 39(3),
34. Faegri, K. 1956. Recent trends in Palynology. *Totan. Rev.* 22:639-644
35. Faegri, K. 1975..(3rd Revised Ed.) Text Book of Pollen Analysis. Blackwell Scientific Publ. Oxford,
36. Faegri, K. and J. Iversen. 1964. (2nd ed.) Text Book of Pollen Analysis. Blackwell Scientific Publ. Oxford.
37. Faegri, K. 1978. What is Polar axis? *Grana* 17: 15-16
38. Ferguson, I.K. and J. Muller (Editors). 1976. The evolutionary significance of the exine. *Linn. Soc. Symp. Ser. No. I* Academic press, London,
39. Heslop-Harrison, J. (1987). Pollen germination and pollen tube growth. *Int. Rev. Cytol.* 107:1-78.
40. Heslop-Harrison, J. 1962. Origin of Exine. *Nature*, 195 (4846): 1069-1071
41. Heslop-Harrison, J. 1971. (Editor). Pollen: Development & Physiology. Butterworths, London,
42. Heslop-Harrison, J. 1976. The adaptive significance of the exine. *Academic Press.* London, *Linn. Soc. Symp. Ser* 1:27-37,
43. Heslop-Harrison, Y. (1981). Stigma characteristics and Angiosperm taxonomy. *Nord J. Bot.* 1:401-420.

44. Heslop-Harrison. J. Heslop-Harrison, Y., Shivanna K.R. (1984). The evaluation of pollen quality and a further appraisal of the fluorochromatic (FCR) test procedure. *Theor. Appl. Genet* 67:367-375.
45. Heywood, V.H. 1967. Plant Taxonomy, Studies in Biology No. 5 Edward Arnold(Publ.) London,
46. Hyde, H.A. and D. A. Williams. 1945. 'Palynology', *Nature*. . 155-265, London
47. Iwanami, Y., Sasakuma, T., Yamada, Y. (1988). Pollen: illustrations and scanning electron micrographs. Kodansha (Tokyo) and Springer, Berlin Heidelberg New YorkTokyo
48. Jain A., Shivanna, K.R. (1988a). Storage of pollen grains in organic solvents: effect of organic solvents on leaching of phospholipids and its relationship to pollen viability. *Ann. Bot.* 61:325-330
49. Jain A., Shivanna, K.R. (1988b). Storage of pollen grains in organic solvents. Effect of solvents on pollen viability and membrane integrity. *J. Plant Physiol.* 132:499-502.
50. Jain A., Shivanna, K.R. (1989). Loss of viability during storage is associated with changes in membrane phospholipid. *Phytochemistry* 28: 999-1002.
51. Knox, R.B., Singh, M.B. (1987). New perspectives in pollen biology and fertilization. *Ann. Bot. Suppl.* 4:15-37.
52. Knox. R.B., Williams, E.G., Dumas, C. (1986). Pollen, pistil and reproductive function in crop plants. *Plant Breed. Rev.* 4:9-79.
53. Koch, K.F. (1972). Fluorescence microscopy. Instruments and applications. Ernst, leitz. Wetzlar, Germany.
54. Maheshwari, P, 1978. An Introduction to the Embryology of Angiosperms, Tata McGraw-Hill Publ. Co. New Delhi
55. Mascarenhas, J.P. 1975. The biochemistry of angiosperm pollen development, *Bot. Rev* 41(3)
56. Mascarenhas. J.P. (1989). The male gametophyte in flowering plants. *Plant Cell* 1:657-664.
57. Moore, P.D., Webb. J.A. (1978). An illustrated guide to pollen analysis. Hodder and Stoughton, London.
58. Mulcahy, D.L., Ottaviano, E., (eds.). (1983). Pollen: biology and implications for plant breeding, Elsevier Biomedical, New York.
59. Muller, J. 1979. Form and Function in Angiosperm Pollen. *Ann. Missouri. Bot. Gard.*- 66(4)
60. Nair, P. K.K. 1965. Trends in the morphological evolution of pollen and spores. *Journs. Indian. Bot. Soc.* XLIV (4):
61. Nair, P.K.K. 1965. Pollen morphology 'of some families of monoclamydeae, *Bot. Notiser*: 118(3) Lund,
62. Nair, P.K.K. 1966. Essentials of Palynology. Asia Publ. House, Bombay,
63. Nair, P.K.K-. 1970. Pollen morphology of Angiosperms. Scholar Publ. House, Lucknow,
64. Nair. P.K.K. 1965. Pollen Grains of Western Himalayan Plants. Asia Publ. House. of pollen vedamse Book (P) Ltd. New Delhi.
65. P. K. K (1970). Pollen morphology of angiosperms. Scholar, Lucknow,
66. Pant, D. D. 1954. Suggestions for the classification and nomenclature of fossil spores and pollen grains. *Bot. Rev.* 20(1). 30-60,
67. Plummer, D.T (1987), An introduction to practical biochemistry (3rd edn). McGraw-Hill. London (Tata Mc-Graw-Hill Edition, 1988).
68. Praglowski, J. 1971. Reticulate and allied exines. *Grana*, 11(2):
69. Ramanna, M.S. (1973). Euparal as a mounting medium for preserving fluorescence of aniline blue in plant material. *Stain Technol* 48.103-105.
70. Rangaswamy, N.S. (1977). Applications of *in vitro* pollination and *in vitro* fertilization. In.. Reinert J., Bajaj. YPS (eds.). Applied and fundamental aspects of plant cell tissue and organ culture. Springer, Berlin, Heidelberg. New York, pp. 412-425.

71. Rowley, J.R. 1967. Fibrils, microtubules and lamellae in Pollen grains. *Rev. Palaeobotan. Palynol* 3:213-226,
72. Rowley, J.R. 1975. Germinal, Apertural Formation in Pollen. *Taxon*. 24(1): 17-25,
73. Saad, S.I. 1963. sporoderm Stratification: The „Medine“ a distinct third layer in the pollen wall. *Pollen et spores*. 5: 17 -38
74. Shivanna, K, R. (1982,). Pollen-pistil-interaction and control of fertilization. In: Johri B.M. (ed.). Experimental embryology of vascular plants. Springer, Berlin Heidelberg New York, pp, 131-174.
75. Shivanna, K.R. (1985). Some applied aspects of pollination biology. *Biol. Mem.* II:113-119.
76. Shivanna, K.R. and Johri, B M 1989. The Angiosperm Pollen: Structure and Function. Wiley Eastern Ltd., New Delhi
77. Shivanna, K.R. and Rangaswami, N.S. 1992. Pollen Biology: A laboratory manual. Narosa Publishing House, New Delhi.
78. Shivanna, K.R. Cresti, M. (1989). Effects of high humidity and temperature stress on pollen membrane and pollen vigour. *Sex Plant Reprod.* 2:137-141.
79. Shivanna, K.R., Heslop-Harrison, J. (1981). Membrane state and pollen viability. *Ann. Bot.* 47:759-779.
80. Shivanna. K.R., Linskens, H.F., Cresti, M. (1991a). Responses of tobacco pollen to high humidity and heat stress: germination in vitro and in vivo. *Sex Plant Reprod* 4:104-109
81. Shukla, A.K., M.R. Vijayraghwan and B. Chaudhari (1998). Biology
82. Sowunmi, M.A. 1976. The potential value of Honey in palaeopalynology and
83. Sporne, K.R. 1972. Some observations on the evolution of pollen types in dicotyledons. *New phytol.* 71:181-185,
84. Stanley, R.G. and H.F. Linskens. 1974. Pollen. Biology, Biochemistry management, Springer-Verlag, Berlin,
85. Stanley, R.G., Linskens, H.F. (1974). Pollen: biology. Biochemistry and management. Springer, Berlin Heidelberg New York.
86. Stanley, R.G., Search, R.W. (1971). Pollen protein diffusates. In Heslop-Harrison-J. (Ed.) Pollen: development and physiology. Butterworths, London, pp 174-176.
87. Steer, M.W, Steer, J.M. (1989). Pollen tube tip growth. *New Phytol.* 111:323-358
88. Swamy, B.G.L. and K.V. Krishnamurthy. 1980 From Flower to Fruit. Tata McGraw- Hill Publisher,
89. Takhtajan A.L. 1980. Outline of the classification of flowering plants (Magnoliophyta). *Bot. rev.* 46(3):
90. Talde U.K. 1994. Advances in Mycology and Aerobiology- Dr S T Tilak commemoration volume.
91. Thanikaimoni, G. (1978). Pollen morphological terms proposed definition-I In Proc. IV Int. Palynol. Conf, Lucknow, Vol. 1, pp. 228-239.
92. Tilak S.T. 1982. Aerobiology, Vaijanti Prakashan, Aurangabad
93. Tilak S.T. 1989. Recent researches in Ecology, Environment and Pollution. Today & Tomorrow Pub., New Delhi
94. Tilak S.T. 1987 “Air monitoring practical Manual”, Vaijanti Prakashan, Aurangabad.
95. Tilak S.T. 2009. Aeromycology. Bharati Printing Press, Pune.
96. Tilak S. T. 1989. Atlas of airborne pollen grains and fungal spores. Vaijanti Prakashan, Aurangabad.
97. Tilak S. T. 1989. Env. Ecology and Aerobiology. Today & Tomorrow’s Printers, New Delhi.
98. Tilak S T and Pande B N 1997. Aerobiology. SatyaJeet Prakashan, Pune.
99. Van Campo, M. 1966-67. et al. Suppl. Electron microscopy's contribution to the Knowledge of the structure of acetolysed pollen grains, I. *Palyn Bull.* II and III

100. Vishnu-Mittre. 1964. Contemporary thought in Palynology. *Phytomorphology*. 14(1):
101. Walker, J.W. 1947. Evolution of exine structure in the pollen of primitive angiosperms. *Amer. J. Bot* 61(8):
102. Walker, J.W. and J.A. Doyle. 1975. The basis of angiosperm phylogeny: Palynology. *Ann. Missouri. Bot. Gard*, 62. 664-723,
103. Walker, J.W. Aperture evolution in the pollen of primitive angiosperms. *Amer. J. Bot.* 61(10): 197b.
104. Walton, John. 1940. An Introduction to the Study of Fossil Plants. Adam and Charles Black, London
105. Wodehouse, R.P. 1935. Pollen Grains. McGraw Hill and Co. New York
106. Wodehouse, R.P. 1936. Evolution of Pollen Grains. *Bot. Rev.* 2- 67-89.
107. Zenkteler, M. (1980). Intra-ovarian and in vitro pollination. In. Vasil I, K.(ed.) Perspectives in plant cell and tissue culture. *Int. Rev. Cytol. Suppl.* 11 B: 137-156.

List of practicals:

Section A. Basic aspects / Pollen Morphology

1. To study structure of stamen
2. Study of permanent slides of microsporogenesis
3. Field study on different pollination mechanism
4. To study structure of pistil
5. Preparation of glycerin jelly
6. Preparation of pollen- Acetolysis technique
7. Preparation of pollen – Wodehouse technique.
8. Study of pollen types using acetolysed and non-acetolysed pollen. Pollen
9. morphology polarity, symmetry, shape, size, sporoderm stratification aperture NPC (To study the pollen types from at least 30 different species, Angiosperms preparation of permanent slides.)
10. Preparation and palynological description in technical language (at least 10 species of Angiosperms).
11. Interpretation of selected electron micrographs (SEM, TEM) of pollen.
12. Preparation, description and identification of spores of Algae, Fungi, Bryophytes, Pteridophytes and pollen types of Gymnosperms.

Section B. Aeropalynology/Melittopalynology/Palaeopalynology (At least two expts.)

13. Use of pollen traps to study local air-spores.
14. Analysis of aerospora slides.
15. Preparation of reference slides by different techniques, culture method (culture of fungi/Algae)
16. Preparation of slides honey samples
17. Analysis of honey samples for qualitative and quantitative study of pollen contents.
18. Estimation of pollen load from bee hive or bees/ pollinator
19. Analysis of coal samples for microfossils with special reference to pollen and spores.
20. Preparation of allergenic extract of pollen.

Section C Pollen Physiology/ecology/biochemistry/ecology. (At least three expts)

21. To study pollen production of the given flowers.
22. To study pollen viability of the given flowers.
23. To study percentage of pollen germination & rate of pollen tube growth.
24. To study different techniques of pollen storage

25. Effect of temperature and relative humidity on viability of stored pollen
26. Effect on Boron and Calcium on pollen germination and tube growth.
27. Semi-vivo technique to study pollen germination and pollen tube growth.
28. Multiple staining for localizing pollen tubes in the pistil
29. To study pollen germination and pollen tube growth in the pistil by employing aniline-blue fluorescence method
30. Cytochemical localization of esterase on stigma surfaces
31. Cytochemical analysis of pollen and pollen tube for various metabolites like proteins, amino acids, carbohydrates, starch, ascorbic acid, DNA, RNA, lipids, lignin, pectin, cellulose, etc (at least five metabolites)
32. Study of pollen contents by paper chromatography/TLC.
33. Colorimetric estimation of proteins/carbohydrates of pollen grains
34. To separate pollen proteins by SDS-PAGE electrophoresis
35. Enzyme bioassay in pollen grains.

Semester III 3T3 - Core Elective I:(Palaeobotany - I)

Module I

Introduction to the science of Petrology- The earth zones, chemical composition of earth crust. The classification of rocks i.e. Endogenetic and Exogenetic (igneous, metamorphic and sedimentary) and their brief account. Glaciations, volcanic eruption and earthquake.

Module II

Geological column and time scale. Physiography of India, Fossilisation, modes of preservation, preparation and age determination and techniques. Systematics, reconstruction and nomenclature. Life in Precambrian, greening of earth –speculation.

Module III

A) How Land Turned Green:- Early Land Plants

i) Rhyniopsida-Rhynia ii) Horneophytosida-Horneophyton

B) Evolution of Microphyllous plants (Silurian-Devonian-Carboniferous)

i) Zosterophytopsida- *Zosterophyllum*, *Asteroxylon*.

ii) Concept of Herbaceous Lycopods of Devonian (Homosporous),

iii) Concept of Herbaceous Lycopods of Carboniferous (Heterosporous)

iv) Arborescent Lycopods of Carboniferous- (*Lepidodendron*, *Lepidophlois*, *Sigillaria*).

v) Trimerophytosida:- Ancestors of Megaphyllous Plants- *Trimerophyton*

Module IV

Diversity of Devonian:-

A) Sphenopsida- Its origin and evolutionary consideration .

i) Sphenophyllales- *Sphenophyllum*

ii) Calamitales- *Calamites*

B) Filicopsida- General characters;

i) Putative Ferns:- a) Pseudosporochnales (*Cladoxylon*, *Pseudosporochnous*)

- b)Stauropteridales-*Stauropteris*
- c)Zygopteridale-*Zygopteris*.

C)Marratiales - *Psaronius*.

D)Filicales-Early Ferns

i)Tedeleaceae

ii)Botryopteridaceae

iii)Anachoropteridaceae

*Note:-

- i. Different plant groups are to be studied with key genera for their morphology and anatomy of vegetative and reproductive parts
- ii. Their evolutionary tendencies with origin should be highlighted

Suggested readings

1. Agashe S.N.(1995)-Palaeobotany , Plants of the past ,their evolution, palaeoenvironment and application in exploration of fossil fuels.Oxford &IBH publishing company-New Delhi.
2. Andrews H.N.(1961)-Studies in Palaeobotany, Willey and Sons –New York.
3. Arnold,C.A.(1947)-An Introduction to Palaeobotany ,MC-Graw Hills.,New York
4. Beck,C.B.and Wight, D.C.(1988)-Progymnosperm, In origin and evolution of Gymnosperms,Columbia Uni. Press-New York.
5. Beck, C.B.(1976)-Current status of the Progymnospermoida, Review of Palaeobotany and Palynology
6. Darrah, W.C.(1960)-Principles of Paleobotany.
7. Erdtman,G(1957)-Pollen and Spore morphology and plant taxonomy.(An introduction to palynology) Hafner Publishing Comp-New York.
8. Chandra,S.and Surange, K.R.(1979)-Revision of the Indian species of Glossopteris, Monograph,Birbal Sahni Institute of Palaeobotany.
9. Hoffmeister,W.S.(1960)-Palynology has an important role in oil exploration.World oil-150:1001-140.
10. Meyen, S.V.(1987) – Fundamentals of Palaeobotany Chapman and Hill,London,New York.
11. Parihar ,N.S.(1995) –Essentials of Palaeobotany,Central Book –Allahabad.
12. Sahni, B.(1964)- Revisions of Indian fossils plants, -III(Monocotyledons) –BSIP-Lucknow.
- 13.Stewart, W.N.& Rothwell,G.V. (1993)-Palaeobotany and Evolution of Plants,Cambridge Univ., Press-Cambridge.
- 14.Venkatchala, B.S & Maheshwari,H.K.(1991)-Palaeobotanical Researches in India.Jour.Ind.Bot.Society-70;1-12
15. Wadia, D.N(1953)-Geology of India,Mac,Millan-Co.London.
16. Prasad, K.N. (1999). - An introduction to palaeobotany, APH Pub.
- 17.Cleal, J. Christopher. &B.A.Thomas (2009)Introduction to Plant Fossils, Cambridge Univ., Press-Cambridge.
- 18.Willis, K.J. & McElwain, J. C.(2014). The Evolution Of Plants(second edition)OXFORD University Press

JOURNALS

- 1.Palaeobotanist
- 2.Geophytology
- 3.Botanique
- 4.Review of Palaeobotany and Palynology
- 5.Journal of India Botanical Society
- 6.American Journal of Botany
- 7.International Palaeobotanical Organization (News),Bulletin

8. Palaeontographica
9. Nature
10. Botanical Gazette
11. Bull. of Botanical Survey of India
12. Bull. of Survey of India
13. Current Science

Suggested Laboratory and Field Exercises

Stratigraphy Maps of the India and World

Geological Maps of India

Geological column and time scale.

Study of different rocks.

Different techniques to study fossils. (Ground sectioning, peel technique) Study different types of fossils.

Study of plant fossils as per syllabus based on specimens and slides.

Study of Rhyniopsida (primitive vascular plants)

Arborescent Lycopods of Carboniferous-study of Lepidodendrales members

Sphenophyllales, Calamitales members.

Study of primitive ferns and their

relatives Cladoxylales, Stauropteridales, Zygopteridales. Marratiales - Psaronius

Preparation of practical record.

Study different types of fossils

Study of plant fossils as per syllabus based on specimens and slides.

Gymnosperm- Caytoniales, Glossopteridales, Pentoxylales. fossil Cordaitales.

Lyginopteridales-Lyginopteridaceae, Medullosaceae, Cycadeoidales-Cycadeoidaceae, Williamsoniaceae and Fossil Cycads (Nilssonina, Baenia.).

Study of Deccan Intertrappean flora of India. Pteridophytes, Gymnosperms and Angiosperms- flowers and fruits.

Important features of spores and pollen morphology and technique to study them (Maceration)

Study of wood anatomy of fossils.

Exploration and excursion to different fossiliferous localities.

Preparation of practical record/submission of collection and tour report of excursion.

Semester III

3T4 - Foundation Course I: General Botany

(Student shall opt for this paper from any other subject other than his/her main subject for post graduation)

Module I: Morphology and Taxonomy

Morphology of- Root, stem, leaf, flower and fruit.

Histology- Cell types and tissue systems in plant, specialized cells

Taxonomy- Classification system of Bentham & Hooker; General characters of- Fabaceae, Solanaceae, Verbanaceae, Liliaceae, Poaceae, Plant identification techniques.

Module II: Biodiversity & Ecotourism

Concept of biodiversity; Types (Species, genetic, ecosystem diversity); present status in India;

Values of biodiversity; Mega-biodiversity centres; CBD- General account.

Aesthetic beauty of wild beautiful plants and their value in nature for Ecotourism point of view in various forests.

Module III: Plant resource utilization

Botany and uses of plants as a source of- fire wood, timber, Non-Wood forest products, cereals, pulses, oilseeds, spices, condiments, narcotics, beverages, fodder, forage, medicine and essential oil (any three of each type).

Module IV: Ecology & Biodegradation of waste

Introduction, concept of ecosystem, types of ecosystems, food chain and food web.

Pollution: Sources, consequences control of soil, air and water pollution. Carbon credit.

Various methods of bio-degradation of waste materials.

Suggested readings

Dash MC 1993. Fundamentals of Ecology. WB Saunders can Co., Philadelphia.

Devis, P.H. and Heywood, V. H. 1973. Principles of angiosperms taxonomy. Robert E. Kreiger Pub. Co. Newyork.

Heywood, V. H. and Moore, D. M. 1984. Current concepts in Plant Taxonomy. Academic Press, London.

Heywood, V. H. and Moore, D. M. 1984. Current concepts in Plant Taxonomy. Academic Press, London.

Jones, S. B., Jr. and Luchsinger, A. E. 1986. Plant Systematics (gd edition). McGraw -Hill Book Co., New York.

Khalid H and Nawaz K 2014. Introductory plant taxonomy. Kalyani Publ., New Delhi.

Kochhar PL 1986. Plant Ecology. Ratan Prakashan, Agra.

Kochhar SL 1998. Economic Botany in tropics 2e. Macmillan India Ltd., New Delhi.

Kumar HD 1994. Modern concepts of ecology. Vikas Publi. House Pvt. Ltd., New Delhi.

Sharma OP 1996 Hill's Economic Botany. TMH Publ. Co. Ltd., New Delhi.

Woodland, D. W. 1991. Contemporary Plant Syatematics, Pentice Hall, New Jersery.

Semester III

3T4 – Core : Aesthetic Botany

Module I – Phytogeography

Climate and Vegetation of the world

Floristic regions of the world. Phytogeographical regions of India; Endemism; Concept of hotspots, hot spots of the world. Forest types of India

Module II – Gardening

Garden Design: Scope and objectives of gardening; Style of gardens (Formal, Informal); Types of gardens (English, Mughal and Japanese)

Components of garden; Planning of outdoor gardens- Small, Residential, Larger Home Garden, Roof Garden, Terrace Garden, Industrial garden, Housing complex, Indoor gardening

Garden Features and Ornamentation: Water, Garden pool, Stream, Waterfall, Fountain, Rocks, Roads, Walks, Pavements and Steps, Walls fences and Gates, Hedges, Edges, Arches, Statues, Towers.

Module III– Floriculture

Nursery production and management: Scope, Site, Soil, Environment, Layout, Manure, Fertilizers, Maintenance, Garden tools, Culture and Garden calendar, Types, Nursery beds, Pest & Disease management.

Propagation of ornamental plants by seeds, bulbs, layering, cuttings, grafting, budding & tissue culture.

Plant disorders including nutrition, pests and diseases, and chimaeras

Ornamental ferns and their propagation; herbaceous perennials, Annuals & Biennials: Important Genera and Species, their importance in garden designs.

Module IV – Landscaping

Landscape Design: Definition, objectives and scope, Landscape elements of construction and designing of Residential, Commercial, Bungalow, Public area, Hotel, Educational Institute and religious places Palms and Cycas: Characteristics, propagation, culture, pest and disease, importance and uses, genera and species of palms and Cycads. Bamboo and conifers: Genera, species and varieties

Lawns & Grasses: Planting methods, maintenance, pest management

Ornamental succulents, Cacti

Polyhouse technology: Scope and objectives of floriculture.

References

Randhawa GS and Mukhopadhyay A. 2004. Floriculture in India. Allied Publishers Pvt. Limited.

Swarup Vishnu. 2003. Garden Flowers. National Book Trust

Hartmann HT, Kester DE, Davies FT and Geneve RL. 2002. Plant Propagation – Principles and Practices. Prentice Hall India Ltd.

Royal Horticultural Society's Encyclopedia of Gardening.

Semester IV
4T1 - Core : Cell and Molecular Biology-II

Module I:

Ribosomes: Structure and function

Transcription: Transcription in prokaryotic and eukaryotic cells, plant promoters, transcription factors, types of RNA and their function, RNA splicing, mRNA transport

Translation: In prokaryotic and eukaryotic cells, structural levels of proteins, post-translational modification; structure and role of rRNA and tRNA.

Module II:

Protein sorting: Protein glycosylation; vesicles involved in protein transport; protein targeting to plastids, mitochondria, peroxisomes, nucleus, vacuoles; modification during transport.

Gene structure: Chemical nature of gene; Fine structure of gene: Classical and modern concept of gene, Cis-trans test; fine structure analysis in eukaryotes; introns and their significance, RNA splicing

Regulation of gene expression: Prokaryotes- Positive and negative control, inducible and repressible operons, lac operon, trp operon, attenuation, riboswitch; Eukaryotes- Regulation at DNA, transcription, translation and post translational level, Epigenetic regulation

Module III:

Genome organization in prokaryotes and eukaryotic organelles: Phage genome, genetic recombination in phage and mapping phage genes; mapping of bacterial genes through transformation, conjugation and transduction; genome of mitochondria and chloroplast.

Genetic recombination and genetic mapping: Recombination; independent assortment and crossing over; molecular mechanism of recombination; role of RecA and RecBCD enzymes; homologous, non-homologous and site-specific recombination; chromosome mapping- linkage group, genetic markers, types of maps, construction of molecular maps, correlation of genetic and physical maps; Somatic cell genetics -an alternative approach to gene mapping.

Module IV:

Cell cycle and apoptosis: Control mechanisms of bacterial and eukaryotic cell cycle, check point control, presence of regulators of cell cycle, G1 – S progression, G2 – M progression, role of cyclins and cyclin dependent kinases; retinoblastoma and E2F proteins; cytokinesis and cell plate formation; Apoptosis and its pathway.

Signal transduction: Overview, receptors and G-proteins, phospholipid signaling, role of cyclic nucleotides, calcium-calmodulin cascades, diversity in protein kinases and phosphatases, specific signaling mechanisms e.g. two-component sensor-regulator system in bacteria and plants, sucrose sensing mechanism

Techniques in cell biology: Electrophoresis, immunotechniques (Western blotting and ELISA), FISH, GISH, confocal microscopy

Suggested readings

Alberts, B., Bray, D., Lewis, J., Raff, M., Roberts, K. and Watson, J.D. 1999.

Molecular Biology of Cell, Garland Publishing, Inc., New York.

Buchanan, B.B., Gruissem, W. and Jones, R. L. 2000 Biochemistry and Molecular Biology of Plants. American Soc. Of Plant Physiologists, Maryland, USA.

De Robertis, E.D.P. and De Robertis, E.M.F. Cell and Molecular Biology 8th Ed. B. I. Waverly Pvt. Ltd., New Delhi.

Jones R, Ougham H, Thomas H, Waaland S 2013 The Molecular life of plants. Wiley-Blackwell, USA

Karp, G. 1999 Cells and Molecular Biology; Concepts and Experiments. John Wiley & Sons, Inc., USA.

Khush, G.s. 1973 Cytogenetics of Aneuploids, Academic Press, New York, London

Kleinsmith, L.J. and Kish, V.M. 1995 Principles of Cell and Molecular Biology (2 nd Edi.) Harper Collins Coll. Publisher, New York, USA.

Lewin, B. 2000 Gene VII Oxford Univ. press, New York.

Lodish, H., Berk, A. Zipursky, S. L. Matsudaira, P., Baltimore, D. and Darnell, J. 2000 Molecular Cell Biology Edi.W.H. Freeman and Co., New York, USA.

Malacinski, G. M. and Freifelder, D. 1998 Essentials of Molecular Biology (3rd Edi.)Jones and Bartiet Pub. Inc., London.

Russel, P. J. 1998 Genetics (5th Edi.) The Benjamin/ Cummings Publishing Com. Inc., USA

Sunstad, D. P. and Simmons, M. J. 2000 Principles of Genetics (2nd Edi.) John Wiley & Sons Inc., USA.

Tamarin, R. H. 2001 Principles of Genetics 7th Edi.The McGraw-Hill Companies.

Wolf, S.L. 1993. Molecular and Cellular Biology, Wadsworth Publishing Co., California, USA.

References: Online journals available on UGC V-SAT programme

Practicals

1. Isolation of nuclei and identification of histones by SDS-PAGE.
2. Isolation of chloroplast and demonstration of two subunits of RUBISCO by SDS-PAGE
3. To perform the restriction digestion of the DNA and analyse the digest over agarose gel.
4. To study *in vitro* transcription.
5. To study *in vitro* translation.
6. To study conjugation in bacterial cells.
7. To detect the presence of specific antigen by ELISA
8. Isolation of RNA and quantification by spectrophotometric method.
9. To map the genes on the basis of given cross-over data.
10. Separation of amino acids by paper electrophoresis, TLC method.
11. Separation of carbohydrates by paper electrophoresis, TLC method.

Semester IV

4T2 - Core: Plant Biotechnology and Plant Breeding

Module I

- a. Recombinant DNA technology: Gene cloning- Principles and technique; vectors- types (cloning & expression; plasmid & viral) and their properties; construction of DNA libraries (gDNA and cDNA); splicing of insert into the vector; screening of DNA libraries and introduction of the recombinant DNA into the host cells.
- b. Genetic engineering of plants: Aims, strategies for development of transgenics (with suitable examples); Agrobacterium-the natural genetic engineer; T-DNA and transposon mediated gene tagging.

Module II

- a. Microbial genetic manipulation: Bacterial transformation, selection of recombinants and transformants, genetic improvement of industrial microbes and nitrogen fixers, fermentation technology.
- b. Genomics and proteomics: Molecular markers for introgression of useful traits; high throughput sequencing; functional genomics; Protein profiling and its significance.

c. DNA synthesis; DNA sequencing; basic polymerase chain reaction and applications of PCR; DNA fingerprinting

Module III

Plant tissue culture: Basic concepts; Principles and scope; tissue culture media; callus induction and cell suspension; aspects of morphogenesis; haploid and triploid production; production of somatic embryos; applications of plant tissue culture; protoplast isolation and culture; production of cybrids

Transgenic production: Methods to introduce gene in plants; selection of transformed plants/explants; salient achievements in crop biotechnology.

Module IV

Bioinformatics: Introduction, History, Definition and applications of bioinformatics; Database: Sequences (nucleotide and amino acid); nomenclature- IUPAC symbols, nomenclature of DNA & protein sequences, directionality of sequences, types of sequences used in bioinformatics; Definitions, types and classification of databases- Primary Databases, Secondary databases, Literature database and Taxonomy database.

Plant breeding: Methods of breeding sexually (self and cross pollinated) and vegetatively propagated crops; heterosis and inbreeding depression and their genetic basis; use of male sterility in hybrid production.

Suggested readings

- Baxeavanis, A. D., Davison, D. B.; Page, R. D. M.; Petsko, G. A.; Stein, L. D. and Stormo, G. D. 2008 Current Protocols in Bioinformatics, John-Wiley and Sons Publications, New York.
- Baxeavanis, A. D. and Ouellate, B. F. F. 2009 Bioinformatics: A Practical Guide to the analysis of genes and proteins. John-Wiley and Sons Publications, New York.
- Brown, T. A. 1999. Genomes, John Wiley & Sons(Asia) Pvt. Ltd., Singapore.
- Callow, J. A., Ford-Lloyed, B. V. and Newbury, H. J. 1997. Biotechnology and Plant Genetic Resources: Conservation and Use, CAB International, Oxon UK.
- Chrispeels, M. J. and Sadava, D. E. 1994, Plants, Genes and Agriculture. Jones & Barlett Publishers, Boston, USA.
- Dubey, R. C. 2014 Advanced Biotechnology. S. Chand & Co. Pvt. Ltd., New Delhi.
- Glazer, A. N. and Nikaido, H. 1995. Microbial Biotechnology. W. H. Freeman & Company, New York, USA.
- Gustafson, R. J. 2000. Genomes. Kluwer Academic Plenum Publishers, New York, USA.
- Henry, R. J. 1997. Practical Applications of Plant Molecular Biology. Chapman & Hall, London, UK.
- Jain, S. M., Sopory, S. K. and Veilleux, R.E. 1996. In vitro Haploid Production in Higher Plants, Vols. 1-5, Fundamental Aspects and Methods. Kluwer Academic Publishers, Dordrecht, The Netherlands.
- Jolles, O. and Jornvall, H. (eds) 2000. Proteomics in Functional Genomics. Birkhauser Verlag, Basel, Switzerland.
- Kartha, K. K. 1985. Cryopreservation of Plant Cells and Organs. CRC Press, Boca Raton, Florida USA.
- Kingsman, S. M. Genetic Engineering : An Introduction to Gene Analysis and Exploitation in Eukaryotes, Blackwell Scientific Publications, Oxford, 1998
- Mount W. 2004 Bioinformatics and sequence genome analysis 2nd Edi. CBS Pub. New Delhi
- Old, R. W. and Primrose, S. B. 1989. Principles of Genome Analysis. Blackwell Scientific Publications. Oxford, UK.
- Primrose, S. B. 1995. Principles of Genome Analysis. Blackwell Scientific Ltd., Oxford, UK.

Raghavan, V. 1997. Molecular Biology of Flowering Plants. Cambridge University Press, New York, USA.

Practicals

1. To study the growth characteristics of *E. coli* using plating and turbidimetric methods.
2. To isolate the plasmid from *E. coli* and quantify it with suitable method.
3. To perform restriction digestion of the given plasmid DNA and to estimate of the size of various DNA fragments.
4. To Clone the given DNA fragment in a plasmid vector.
5. To prepare competent cells from the given bacterial culture.
6. To transform the competent bacterial cells with the given vector and perform blue-white selection.
7. To prepare the media for plant tissue culture.
8. To surface sterilize the given seeds/explant for tissue cultural manipulation.
9. To isolate protoplast and determine its viability.
10. To fuse the protoplast for production somatic hybrid.
11. To work out the DNA sequence from the given autoradiogram and identify the gene using online tools.
12. To search literature database of different organisms.
13. To search the genes in the Genbank.
14. To use the various tools to retrieve information available from NCBI
15. To locate gene(s) on chromosomes for a given disease/disorder.

Suggested Readings(for laboratory exercises)

Baxevanis, A. D. and Ouellate, B. F. F. 2009 Bioinformatics: A Practical Guide to the analysis of genes and proteins. John-Wiley and Sons Publications, New York.

Glover, D. M. and Hames, B. D.(Eds) 1995. DNA Cloning 1: A Practical Approach: Core Techniques, 2nd edition PAS, IRL Press at Oxford University Press, Oxford.

Hackett, P. B. Fuchs, J. A. and Messing, J. W. 1988. An Introduction to Recombinant DNA Techniques. Basic Experiments in Gene Manipulation. The Benjamin/cummings Publishing Co., Inc. Menlo Park, California.

Maniatis et al. Molecular cloning Vol.I, II and III. Cold-Spring Harbor Lab Press.

Shaw, C. H. (Ed.) 1988, Plant Molecular Biology : A Practical Approach. IRL Press, Oxford.

References: Online journals available on UGC V-SAT programme.

Semester IV

4T3 -Core Elective II:(Molecular Biology and Plant Biotechnology - II)

Module I:

Transgenic plants: Cloning vectors for higher plants; Methods for gene transfer, *Agrobacterium tumefaciens* mediated gene transfer-Basis of tumour formation, features of Ti and Ri plasmids, mechanisms of DNA transfer, role of virulence genes; Direct DNA transfer- particle bombardment, electroporation, microinjection, macroinjection, liposomes, electrophoretic; pollen tube method; pollen transformation; PEG method; transformation of monocots; transgene stability and gene silencing; chloroplast transformation.

Module II:

- a. Applications of transformation: Herbicide resistance; insect resistance; Bt genes, disease resistance; Nutritional quality; biopesticides and biofertilizers; hazards and safety regulations for transgenic plants.
- b. Transgenics and molecular farming: Production of secondary metabolites; industrial enzymes; biodegradable plastics (PHB and any other); edible vaccines; antibody production and other important drugs.

Module III:

Plant tissue culture: History, Culture types- Callus culture, organ culture, suspension culture for production of secondary metabolites, protoplast culture, fusion and somatic hybrids, Somatic embryogenesis, production of haploid plants, somaclonal variations, organogenesis (direct and indirect).

Module IV:

- a. DNA fingerprinting and marker assisted breeding: RFLP maps; linkage analysis; RAPD markers; STS; SSR (microsatellites); ISSR; SCAR (sequence characterized amplified regions); SSCP (single strand conformational polymorphism); AFLP; QTL: map based cloning; molecular marker assisted selection
- b. Cleaner Biotechnology: Pollution control through genetically modified organisms; types of pollutants, bioremediation and phytoremediation; Production of bioethanol, biodiesel and biohydrogen.

Suggested readings

- Alberts, Bruce; Johnson, Alexander; Lewis, Julian; Raff, Martin; Roberts, Keith; Walter, Bhojwani SS and Rajdhan MK 1996 Plant tissue culture: Theory and Practice. Elsevier Sci. Publ., New York
- Peter 2002 Molecular Biology of the Cell, New York and London: Garland Science.
- Callow, J. A., Ford-Lloyd, B. V. and Newbury, H. J. 1997. Biotechnology and Plant Genetic Resources: Conservation and Use, CAB International, Oxon UK.
- Charlwood, B. Y. and Rhodes, M.V. 1999 Secondary products from plant tissue culture, Clarendon Press. Oxford.
- Chrispeels, M. J. and Sadava, D. E. 1994, Plants, Genes and Agriculture. Jones & Barlett Publishers, Boston, USA.
- Collins HA and Edwards S 1998 Plant cell culture. BIOS Sci. Publ., Oxford UK
- Dicosmo F and Misawa, M. 1996 Plant Cell culture: Secondary metabolism towards industrial application, CRC press, Boca Raton, New York.
- Glazer, A. N. and Nikaido, H. 1995. Microbial Biotechnology. W. H. Freeman & Company, New York, USA.
- Gustafson, R. J. 2000. Genomes. Kluwer Academic Plenum Publishers, New York, USA.
- Henry, R. J. 1997. Practical Applications of Plant Molecular Biology. Chapman & Hall, London, UK.
- Jain SM, Sopory SK and Veilleux RE 1996 In vitro haploid production in higher plants. Vols. 1-5. Kluwer Acad. Publ., The Netherlands
- Kurz, W.G.W 1989 Primary and Secondary metabolism of plant and Cell cultures, Springer Verlag, Berlin.
- Old, R. W. and Primrose, S. B. 1989. Principles of Genome Analysis. Blackwell Scientific Publications. Oxford, UK.
- Primrose, S. B. 1995. Principles of Genome Analysis. Blackwell Scientific Ltd., Oxford, UK.

Raghavan, V. 1997. Molecular Biology of Flowering Plants. Cambridge University Press, New York, USA.

Shantharam, S. and Montgomery, J. F. 1999. Biotechnology, Biosafety, and Biodiversity. Oxford & IBH Publication Co., Pvt., Ltd., New Delhi.

Semester IV

4T3 - Core Elective II: (Mycology and Plant Pathology -II)

Module I:

History: Milestones in phytopathology with particular reference to India. Major epidemics and their social impacts. Historical developments of chemicals, cultural and biological protection measures.

Altered metabolism of plants under biotic and abiotic stresses.

Koch's Postulates

Epidemiology and forecasting of plant diseases

Indian Institutes and their research activities in Mycology and Plant Pathology

Module II: Principles of Plant pathology

i. Principles of plant pathology-Importance, nature, classification and general symptoms of plant diseases.

ii. Pathogenecity of microorganisms and pathogenesis.

iii. Host parasite relationship and Interaction; Signal transduction.

iv. Defence mechanism in host plants against pathogens -morphological or structural defence mechanism; Biochemical defence mechanisms - role of phenolic compounds, enzymes and toxins,

v. Principles and methods of plant disease control -cultural methods, chemical methods, Biological control, transgenic approach for plant disease control, integrated pest management (IPM), Biopesticides.

Module III:

A Detailed study of the Diseases of the following crops caused by fungal pathogens with effective control measures.

Diseases of Cereals: Seedling blight of cereals, Smut of wheat, Foot rot of wheat, Covered smut of Barley, False smut of rice, Downey mildew of jowar, Green ear disease of Bajra, Ergot of Bajra, Downey mildew of maize.

Diseases of Vegetable crops with special reference to the important diseases of the following: Chilli, Brinjal, Tomato, Onion, Bhindi.

General knowledge of post harvest diseases of fruits and vegetables and their control.

Diseases of Oil Seed Crops viz. *Linum*, *Seasamum*, Groundnut, Mustard and Sunflower

Diseases of Fruit Trees-With special reference to important diseases of the following Citrus, Apple, Mango, Banana and Grapes.

Module-IV:

Bacterial diseases of plants - Bacterial blight of rice, Tundu disease of wheat, Angular leaf spot of cotton, stalk rot of maize, Fire blight of Apple, Bacterial soft rot of fruits and Vegetables.

Viral Diseases of Plant: Bunchy top of Banana, Leaf curl of Papaya, Yellow vein mosaic of Bhindi. Mosaic of Cucurbits, Viral diseases of Tobacco, Potato and Tomato.

Mycoplasma/Phytoplasma (PPLo) Diseases of Plants: Citrus greening, Rice yellow dwarf: Little leaf of Brinjal, Sandal Spike.

Nematode Diseases of Plants: General knowledge of plant parasitic nematodes and important nematode diseases viz. Root knot of Vegetables, Ear cockle of wheat. .

Suggested readings

1. Agrios, G.N. (1980) Plant Pathology, academic Press, INC, New York.
2. Ainsworth, G.C. and A.S.Sussman (eds). The Fungi, An advance Treatise Vol.I, II, III & IV Academic Press, New York.
3. Alexopoulos, C.J. (1962). Introductory Mycology John Wiley Eastern Pvt.Ltd.
4. Alexopoulos, C.J. and Mims C.W. (1979). Introductory Mycology 3rd Edition, John Wiley and Sons, Inc. Wiley, New York.
5. Alexopoulos, C.J., Mims and Black well (1996) 4th ed. John Wiley and Sons, Inc. Wiley, New York
6. Aneja, K.R. (1993) Experimental in Microbiology, Plant Pathology & Tissue Culture, Wiswa Prakashan, New Delhi.
7. Bessey, E.A. (1950) Morphology and Taxonomy of Fungi. The Blakiston co. Philadelphia.
8. Bilgrami, K.S. and H.C.Dube (1985) A text Book of Modern Plant Pathology, Vikas Publication House, New Delhi.
9. Barnett, J.H. (1968) Fundamentals of Mycology. The English Language Book Society and Edward Arnold Publication, Limited.
10. Dube, R.C. and D.K.Maheshwari (1999) A.Text Book of microbiology, S.Chand & Co. Ltd.
11. Dube, R.C. and D.K.Maheshwari (2000) Practical Microbiology -S.Chand & Co. Ltd.
12. Gupta, V.K. and M.K.Behl (1994) Indian Plant Viruses and Mycoplasma Kalyani Publishers, 1/1, Rejinder Nagar, Ludhiana.
13. Jha, D.K. (1993) A Text Book of Seed Pathology, Vikas Publication House.
14. Mehrotra, R.S. (1989) Plant Pathology, Tata McGraw Hill.
15. Mehrotra, R.S. and K.R.Aneja (1998) An Introduction to Mycology, New Age Intermediate Press.
16. Pelzer, M.J. , Jr.Cahn, E.C.S. and N.R.Krieg (1993) Microbiology, Tata McGraw Hill.
17. Preece and Dickeson. Ecology of leaf surface microorganism Academic Press, New York.
18. Rangaswamy, G. and A.Mahadevan (1999) Diseases of Crop Plant in India, Prentice Hall of India.
19. Raychoudhari, S.P. and Nariani, T.K. (1977) Virus and Mycoplasma Diseases of Plant in India, Oxford and IBH Publication Co.
20. Schlegel, H.G. (1996) General Microbiology, 7th Edition, Cambridge University Press.
21. Snowdon, A.L. (1991) A colour Atlas of Post harvest diseases & disorders of fruits & vegetables Vol.I & II Wolfe Scientific, London.
22. Sunder Rajan, S. (2001) Tools and Techniques of Microbiology, Anmol Publ.New Delhi.
23. Thind, T.S. (1998) Diseases of field crops and their management, National Agricultural Technology, Information Centre, Ludhiana.
24. Vaidya, J.G. (1995) Biology of the fungi, Satyajeet Prakashan, Pune.
25. Walker, J.G. (1952) Diseases of Vegetables Crops. McGraw Hill, New York.
26. Walker, J.C. (1968) Plant Pathology, McGraw Hill, New York.
27. Eggins, H.O.W. and Allsop (1975) The Filamentous Fungi Vol. I Industrial Mycology (Biodeterioration and Biodegradation by Fungi) Eds. J.E. Smith and D.R. Berry Edward Arnold, London.
28. Emmons, C. W., C. H. Bin ford, J.P. Utz and Know Chung (1977) Medical Mycology, Lea and Febigo, Philadelphia.

29. Holliday, P. Fungus disease of tropical plants (1980), Cambridge University Press, Cambridge.

On line Journals available on UGC -VSAT

Semester IV
4T3 - Core Elective II:(Reproductive Biology of Angiosperms - II)

Module I:

Fertilization: Cellular nature of sperm, the sperm cytoskeleton, the male germ unit, isolation and characterization of sperm, growth of the pollen tube through the style, passage of sperm into the embryo sac, fusion of nuclei, double fertilization, triple fusion, unusual features. In-vitro approaches to the study of fertilization-Intra-ovarian pollination, test tube fertilization, in-vitro fertilization, placental pollination, Gynogenesis.

Endosperm: types of endosperms, ruminant endosperm, cytological status. endosperm haustoria, chemical composition of endosperm, food reserve in endosperm, role of endosperm in embryo development, endosperm mutants.

Module II:

Embryogenesis: Zygote and its ultra-structure, Johanssen's system of embryo development, symmetry and polarity, rest period in zygote embryonic formulae, embryonic law. Suspensor-Ultra structure of suspensor cells, cytology of suspensor cell, physiology and biochemistry of suspensor; Nutrition of embryo-nutrient supply of the zygote, embryo-endosperm relation.

Polyembryony: Definition, causes, classification, induction of polyembryony, practical importance of polyembryony.

Module III:

Apomixis: Definition, causes, classification, -Diplospory, Apospory, pseudogamy, autogamous development of endosperm, causes of apomixis, significance.

Parthenocarpy: Definition, causes, practical importance

Mellitopalynology: Pollen analysis of honey, Role of apiculture in crop production.

Biotechnology: Concept and scope of biotechnology; Cell structure, cellular totipotency

a) Anther and pollen culture,

b) Ovule and nucellus culture

c) Endosperm culture and its practical applications

Module IV:

d) Embryo culture: Techniques, nutritional aspects of embryo culture morphological and physiological considerations, culture of mature embryo and proembryo.

e) Somatic embryogenesis: historical background, embryogenesis from callus, direct embryogenesis-recurrent embryogenesis; cytology of somatic embryogenesis, nutritional factors, hormonal factors.

f) Protoplast culture and somatic hybridization-isolation of protoplast, culture methods, fusion of protoplast, selection of fusion products, consequences of fusion, production of Cybrids and hybrids.

g) Biotransformation and production of useful compounds through cell culture, factor affecting yield, biotransformation, bioreactors, perspective.

Semester IV
4T3 - Core Elective II:(Plant Physiology - II)

Module-I

Secondary metabolites :-Introduction and classification, Secondary metabolites and ecological functions in plants , secondary metabolites defend plants against herbivores and pathogens

a. Alkaloids:- alkaloid biosynthesis, Biotechnological application of alkaloids Biosynthesis, plant defense against pathogens

b. Terpenoids:- terpenoids and herbivory, steroids and sterols, polyterpens, prenyltransferase and terpene synthase reactions, modifications of terpenoid skeletons toward transgenic production

c. Phenolic compounds:- medicinal properties of phenolic compounds, types- simple phenolics, coumarins, lignin, flavonoids, tannins

d. Glycosides:-saponins, cardiac glycosides, cyanogenic glycoside, glucosinolates

Module-II

Leaf protein: - Green crop fractionation (GCF), Leaf Protein Concentrate (LPC), Chloroplastic LPC, Cytoplasmic LPC, Deproteinised Leaf Juice (DPJ), Uses of DPJ. Importance of leaf protein

Industrial fermentation:- importance of fermentation, type of fermentation, alcoholic fermentation, enzyme production , antibiotic production

Biodiesel production:- introduction and historical account of biodiesel, methods of preparation biodiesel from vegetable oil, biochemical properties of biodiesel Importance of biodiesel.

Module-III

Plant Neuro/electro physiology:- introduction and historical account of plant electrophysiology, Factor affecting electrical potential, electrodes and methods used for Measuring the Electrical potential energy of plants and fruits

Signal Perception and Transduction:- Introduction, overview of signal transduction pathway, receptors, specific examples of plant receptors, signal transduction in Prokaryotes, signal transduction in eukaryotes, G-proteins and phospholipids signaling, cyclic nucleotides, secondary messengers (Calcium, calcium-calmodulin complexes, Protein kinases particular pathways of signal transduction Associated with plant growth regulators

Module-IV

Vitamins:- water and fat- soluble vitamins, biochemical function of thiamine, riboflavin, nicotinic acid, pantothenic acid, pyridoxin, biotin, folic acid, vitamin B12, ascorbic acid, vitamin A and vitamin D

Antioxidants:- what are antioxidants, types of antioxidants, role of antioxidants in medicine and in disease control, cure and prevention, antioxidant rich foods

Nanobiotechnology:- Application of nano-biotechnology in medicine and food, synthetic and natural bionanomaterials. Implications of nanoscience and nanotechnology on society.

Issues- biosensors and their applications, biological nanostructures. Applications of bionanoscience to materials research.

Semester IV
4T3 - Core Elective II:(Palynology - II)

Module I: Pollen physiology and biochemistry-

Pollen production, Pollenviability, tests for pollen viability, Pollen germination of pollen *in vivo* and *in vitro*, germination requirements, Role of boron and calcium in pollen germination, Factors affecting pollen germination. Chemical composition of pollen wall and pollen contents (amino acids, proteins, carbohydrates, lipids, vitamins, pectin, DNA, RNA, ascorbic acid, flavones, pigments etc.). Fine structure inside the tube, pollen culture movements of nuclei-and formation of calloseplug, promotion and inhibition of pollen tube, elongation, pollen enzymes and isozymes.

Module II: Pollen biotechnology and genetics, forensic palynology

Pollen storage-Factors affecting viability in storage, freeze-drying of pollen, storage of pollen in organic solvents, causes of decreased viability in storage and pollen germination.

Pollen-pistil interaction- significance, self incompatibility (regulation of fertilization) Pollen biotechnology & crop production- Anther / pollen culture, production of haploids

Genetics of pollen: Genetic segregation of pollen, pollen sterility- genic and cytoplasmic male sterility, factors involved in male sterility. Male sterility through recombinant DNA technology.

Forensic palynology- Introduction, methodology, role in criminology, examples

Module III:

Aerobiology-Introduction, Historical background, applications of Aeropalynology, Aeromycology, Aerophycology. Importance in medical field, importance of aero mycological studies in various types of crop infection by spores, disease forecasting, aerobiological work in India and abroad.

Intramural and extramural studies, different devices to collect spores, pollen grains such askite, balloons, trap air strips and slides, volumetric samplers, culturing techniques, analysis of data and their processing, seasonal changes of air-spores, Indoor environments, Outdoor airspores, characteristics, identification

Module IV:

Airborne allergens- Introduction, allergens and their types, Impact of airborne materials on human system, Lung as particulate sampler, Source, causes, symptoms of Pollen allergy, fungal spore allergy, dust mite allergy, algal allergy other allergies, pollinosis, nasobroncheal allergy, Prevention and cure, Human immunoglobulins- types, and significance in diagnosis of allergy, diagnosing allergic diseases, Testing and treatment standardization, pollen calendar and daily census of airborne pollen, Correlation between aerobiological, clinical and meteorological data.

Recommended reading

1. Afzelius, B.M. 1956 Electron-microscope investigation into exine stratification GranaPalynologica (N.S.) 1:2,
2. Agashe S. N. – Paleobotany (1997) – Plants of the past their evolution paleoenvironment and applications in exploration of Fossil.
3. Agashe S. N. – Palynology and its Applications – Oxford and IBH Publishing Co. Pvt. Ltd. New Delhi.
4. Alexander M.P. (1969). Differential staining of aborted and non-aborted pollen Stain Technol 44:117-122.

5. Alexander, M.P. (1987). A method for staining pollen tubes in pistil. *Stain Technol* 62, 107-112.
6. Alexander, M.P., Ganeshan S. (1990). An improved cellophane method for in vitro germination of recalcitrant pollen. *Stain Technol* 64:225-227. *Archaeology, Rev. Palaeobot. Palynol* 21:171-185,
7. Baker, H.G. 1954. Aperture membranes in *Studies of Pollen Morphology and Taxonomy*. *Newphytologist*, 54(3),
8. Banerjee, U.C. 1965, et al. Exine plasticity during pollen grain maturation. *J. palynol.*: 70-89,
9. Banerjee, U.C. 1967. Ultrastructure of the tapetal membranes in grasses. *Grana palynologica*: 7,2-3,
10. Bhattacharya K., Majumdar M. and Gupta Bhattacharya S. (2006). A text book of Palynology. New Central Book Agency(P) Ltd., Kolkata
11. Bhojwani, S .S. and S.P. Bhatnagar. 1978. *The Embryology of Angiosperms*. Vikas Publishing House, New Delhi,
12. Bir Bahadur 1998. *Nectary biology*. Datt sons publications, Nagpur Bombay,
13. Brooks. J. and G. Sha'w. 1978. Sporopollenin: A review of its chemistry, palaeochemistry and Geochemistry. *Grana*. 17(2) : 91-98.
14. Caulton Eric, Agashe S. N. -Pollen and Spores applications with special emphasis on Aerobiology and Allergy 15.
- Chowdhary, J.B. and T.M. Varghese. 1968. Pollen sterility in crop plants-A review *Palyn. Bull.* IV (2).
16. Colombo P.M., Lueehin F., Colombo B. (1977). On the control of the population effect on in vitro assays of pollen germination. *J Exp. Bot.* 28:425-438.
17. Cresti, M., Gori P., Pacini E. (eds.) (1988) *Sexual reproduction in higher plants*. Springer, Berlin Heidelberg New York Tokyo.
18. Cronquist, A. 1968. *The evolution and classification of flowering plants*, Nelson, London
19. Dafni Amots, Hesser Michel, Paeini Ettore – *Pollen and Pollination*-Springer Wien New York
20. Davis. P.H. and V.H. Heywood. 1963. *Principles of Angiosperm Taxonomy*. Oliver and Boyd, London,
21. Dumas C, Knox R.B. (1983). Callose and determination of pistil viability and incompatibility. *Theor Appl. Genet* 67: 1 -10.
22. Echlin, P. Pollen. 1968. *Scientific American* 218(4),
23. EI-Gazzar and M.K. Hamza. 1973. Morphology of the twin Pollinia of *Asclepiadaceae*. *Pollen et spores* XV (3-4)
24. Erdtman, G, (1956) "Lo-analysis" and "Welcker's rule". *Sven Bot. Tidskr.* 50:1-7.
25. Erdtman, G. 1945. *Pollen Morphology and Plant Taxonomy IV Labiatae, Verbenaceae, Avicenniaceae*. *Svensk Botanisk Tidskrift*. 39(3),
26. Erdtman, G. (1966). *Pollen morphology and plant taxonomy angiosperms* hafner. New York.
27. Erdtman, G. (1969). *Handbook of Palynology*. Hafner, New York
28. Erdtman, G. 1943. *An Introduction to Pollen Analysis*. *Chronica Botanica Co.*, Waltham, Mass. pp. 239,
29. Erdtman, G. 1952. *Pollen Morphology and Plant Taxonomy (An Introduction to Palynology-1, Angiosperms)*. Aimqvist, and Wicksell, Stockholm,
30. Erdtman, G. 1956. *Current Trends in Palynological Research Work Grana Palynologica (N.S.)* 1:2,
31. Erdtman, G. 1960. The Acetolysis method revised description *Su. Bot. Tidskr.* 54(4).
32. Erdtman, G. 1964. *Palynology*. In: W.B. Turrill (Editor) *Vistas in Botany*. Macmillan Go., New York, Vol. 4:23-54,

33. Erdtman, G. 1945. Pollen Morphology and Plant Taxonomy V on the occurrence of tetrads and dyads. *Su. Bot. Tidsker.* 39(3),
34. Faegri, K. 1956. Recent trends in Palynology. *Totan. Rev.* 22:639-644
35. Faegri, K. 1975..(3rd Revised Ed.) *Text Book of Pollen Analysis.* Blackwell Scientific Publ. Oxford,
36. Faegri, K. and J. Iversen. 1964. (2nd ed.) *Text Book of Pollen Analysis.* Blackwell Scientific Publ. Oxford.
37. Faegri, K. 1978. What is Polar axis? *Grana* 17: 15-16
38. Ferguson, I.K. and J. Muller (Editors). 1976. *The evolutionary significance of the exine.* Linn. Soc. Symp. Ser. No. I Academic press, London,
39. Heslop-Harrison, J. (1987). Pollen germination and pollen tube growth. *Int. Rev. Cytol.* 107:1-78.
40. Heslop-Harrison, J. 1962. Origin of Exine. *Nature*, 195 (4846): 1069-1071
41. Heslop-Harrison, J. 1971. (Editor). *Pollen: Development & Physiology.* Butterworths, London,
42. Heslop-Harrison, J. 1976. The adaptive significance of the exine. *Academic Press.* London, Linn. Soc. Symp. Ser 1:27-37,
43. Heslop-Harrison, Y. (1981). Stigma characteristics and Angiosperm taxonomy. *Nord J. Sot.* 1:401-420.
44. Heslop-Harrison, J. Heslop-Harrison, Y., Shivanna K.R. (1984). The evaluation of pollen quality and a further appraisal of the fluorochromatic (FCR) test procedure. *Theor. Appl. Genet* 67:367-375.
45. Heywood, V.H. 1967. *Plant Taxonomy, Studies in Biology No. 5* Edward Arnold (Publ.) London,
46. Hyde, H.A. and D. A. Williams. 1945. 'Palynology', *Nature.* . 155-265, London
47. Iwanami, Y., Sasakuma, T., Yamada, Y. (1988). *Pollen: illustrations and scanning electron micrographs.* Kodansha (Tokyo) and Springer, Berlin Heidelberg New York Tokyo
48. Jain A., Shivanna, K.R. (1988a). Storage of pollen grains in organic solvents: effect of organic solvents on leaching of phospholipids and its relationship to pollen viability. *Ann. Bot.* 61:325-330
49. Jain A., Shivanna, K.R. (1988b). Storage of pollen grains in organic solvents. Effects of solvents on pollen viability and membrane integrity. *J. Plant Physiol.* 132:499-502.
50. Jain A., Shivanna, K.R. (1989). Loss of viability during storage is associated with changes in membrane phospholipid. *Phytochemistry* 28: 999-1002.
51. Knox, R.B., Singh, M.B. (1987). New perspectives in pollen biology and fertilization. *Ann. Bot. Suppl.* 4:15-37.
52. Knox, R.B., Williams, E.G., Dumas, C. (1986). Pollen, pistil and reproductive function in crop plants. *Plant Breed. Rev.* 4:9-79.
53. Koch, K.F. (1972). *Fluorescence microscopy. Instruments and applications.* Ernst, leitz. Wetzlar, Germany.
54. Maheshwari, P, 1978. *An Introduction to the Embryology of Angiosperms,* Tata McGraw-Hill Publ. Co. New Delhi
55. Mascarenhas, J.P. 1975. The biochemistry of angiosperm pollen development, *Bot. Rev* 41(3)
56. Mascarenhas, J.P. (1989). The male gametophyte in flowering plants. *Plant Cell* 1:657-664.
57. Moore, P.D., Webb, J.A. (1978). *An illustrated guide to pollen analysis.* Hodder and Stoughton, London.
58. Mulcahy, D.L., Ottaviano, E., (eds.). (1983). *Pollen: biology and implications for plant breeding,* Elsevier Biomedical, New York.
59. Muller, J. 1979. Form and Function in Angiosperm Pollen. *Ann. Missouri. Bot. Gard.* 66(4)

60. Nair, P K.K. 1965. Trends in the morphological evolution of pollen and spores. *Journs.Indian. Bot. Soc.* XLIV (4):
61. Nair, P.K.K. 1965.Pollen morphology 'of some families of monochlamydeae, *Bot. Notiser:* 118(3) Lund,
62. Nair, P.K.K. 1966.Essentials of Palynology. Asia Publ. House, Bombay,
63. Nair, P.K.K-. 1970.Pollen morphology of Angiosperms. Scholar Publ. House, Lucknow,
64. Nair. P.K.K. 1965.Pollen Grains of Western Himalayan Plants.Asia Publ. House.of pollen vedamse Book (P) Ltd. New Delhi.
65. P. K. K (1970). Pollen morphology of angiosperms. Scholar, Lucknow,
66. Pant, D. D. 1954. Suggestions for the classification and nomenclature of fossil spores and pollen grains.*Bot. Rev.* 20(1). 30-60,
67. Plummer, D.T (1987), An introduction to practical biochemistry (3rd edn). McGraw-Hill.London (Tata Mc-Graw-Hill Edition, 1988).
68. Praglowski, J. 1971. Reticulate and allied exines. *Grana*,11(2):
69. Ramanna, M.S.(1973). Euparal as a mounting medium for preserving fluorescence of aniline blue in plant material. *Stain Technol* 48.103-105.
70. Rangaswamy, N.S. (1977). Applications of in vitro pollination and in vitro fertilization. In.. Reinert J., Bajaj. YPS (eds.). *Applied and fundamental aspects of plant cell tissue and organ culture.* Springer, Berling, Heidelberg. New York, pp. 412425.
71. Rowley, J.R. 1967. Fibrils, microtubules and lamellae in Pollen grains. *Rev. Palaeobotan. Palynol* 3:213-226,
72. Rowley,'J.R. 1975. Germinal, Apertural Formation in Pollen.*Taxon.* 24(l): 17-25,
73. Saad, S.I. 1963.sporoderm Stratification: The „Medine. a distinct third layer in the pollen wall. *Pollen et spores.* 5: 17 -38
74. Shivanna, K, R. (1982,). Pollen-pistil-interaction and control of fertilization. In: Johri B.M. (ed.). *Experimental embryology of vascular plants.* Springer, Berlin Heidelberg New York, pp, 131-174.
75. Shivanna, K.R. (1985). Some applied aspects of pollination biology. *Biol. Mem. II:* 113-119.
76. Shivanna, K.R. and Johri, B M 1989. *The Angiosperm Pollen:Structure and Function.* Wiley Eastern Ltd., New Delhi
77. Shivanna, K.R. and Rangaswami, N.S. 1992. *Pollen Biology: A laboratory manual.* Narosa Publishing House, New Delhi.
78. Shivanna, K.R. Cresti, M. (1989). Effects of high humidity and temperature stress on pollen membrane and pollen vigour. *Sex Plant Reprod.* 2:137-141.
79. Shivanna, K.R., Heslop-Harrison, J. (1981). Membrane state and pollen viability. *Ann. Bot.* 47:759-779.
80. Shivanna. K.R., Linskens, H.F., Cresti, M. (1991a). Responses of tobacco pollen to high humidity and heat stress: germination in vitro and in vivo. *Sex Plant Reprod* 4: 104-109
81. Shukla, A.K., M.R.Vijayraghwan and B.Chaudhari (1998). *Biology*
82. Sowunmi, M.A. 1976. The potential value of Honey in palaeopalynology and
83. Sporne, K.R. 1972. Some observations on the evolution of pollen types in dicotyledons.*Newphytol.* 71:181-185,
84. Stanley, R.G. and H.F. Linskens. 1974. *Pollen. Biology, Biochemistry management,* Springer-Verlag, Berlin,
85. Stanley, R.G., Linskens, H.F. (1974). *Pollen: biology. Biochemistry and management.* Springer, Berlin Heidelberg New York.
86. Stanley, R.G., Search, R.W. (1971). Pollen protein diffusates.In Heslop-Harrison-J. (Ed.) *Pollen: development and physiology.* Butterworths, London, pp 174-176.
87. Steer, M.W, Steer, J.M. (1989). Pollen tube tip growth. *New Phytol.* 111:323-358

88. Swamy, B.G.L. and K.V. Krishnamurthy. 1980 From Flower to Fruit. Tata McGraw-Hill Publisher,
89. Takhtajan A.L. 1980. Outline of the classification of flowering plants (Magnoliophyta). Bot.rev. 46(3):
90. Talde U.K. 1994.Advances in Mycology and Aerobiology-Dr S T Tilak commemoration volume.
91. Thanikaimoni, G. (1978). Pollen morphological terms proposed definition-I In Proc. IV Int. Palynol. Conf, Lucknow, Vol. 1, pp. 228-239.
92. Tilak S.T. 1982. Aerobiology, Vaijyanti Prakashan, Aurangabad
93. Tilak S.T.1989. Recent researches in Ecology, Environment and Pollution. Today & Tomorrow Pub., New Delhi
94. Tilak S.T. 1987 "Air monitoring practical Manual", Vaijanti Prakashan, Aurangabad.
95. Tilak S.T. 2009. Aeromycology. Bharati Printing Press, Pune.
96. Tilak S. T. 1989. Atlas of airborne pollen grains and fungal spores. Vaijayanti Prakashan, Aurangabad.
97. Tilak S. T. 1989. Env.Ecology and Aerobiology.Today & Tomorrow.s Printers, New Delhi.
98. Tilak S T and Pande B N 1997. Aerobiology. Satyajeet Prakashan, Pune.Van Campo, M. 1967. Pollen at classification, Rev. Palaeobotan. Palynol 3:65-71.
99. Van, Campo, M. 1966-67. et al. Suppl. Electron microscopy's contribution to the Knowledge of the structure of acetolysed pollen grains, I. Palyn Bull. II and III
100. Vishnu-Mittre. 1964.Contemporary thought in Palynology. Phytomorphology. 14(1): 101.
- Walker, J.W. 1947.Evolution of exine structure in the pollen of primitive angiosperms. Amer. J. Bot 61(8): 102.
- Walker, J.W. and J.A. Dolye. 1975. The basis of angiosperm phylogeny: Palynology. Ann. Missouri. Bot. Gard, 62. 664-723,
103. Walker, J.W. Aperture evolution in the pollen of primitive angiosperms. Amer. J. Bot. 61(10): 197b.
104. Walton, John. 1940. An Introduction to the Study of Fossil Plants. Adam and Charles Black, London
105. Wodehouse, R.P. 1935.Pollen Grains. McGraw Hill and Co. New York
106. Wodehouse, R.P. 1936. Evolution of Pollen Grains.Bot. Rev. 2-67-89.
107. Zenkteler, M. (1980). Intra-ovarian and in vitro pollination. In. Vasil I, K. (ed.) Perspectives in plant cell and tissue culture. Int. Rev. Cytol. Suppl. 11 B: 137156.

Semester IV

4T3- Core Elective II:(Palaeobotany - II)

Module I

Progymnospermopsida:- Free sporing plants with Gymnosperm Wood Anatomy.Concept of Progymnosperm,Aneurophytales and Archaeopteridales, Protopytales, Origin of Progymnospermopsida.

Gymnospermopsida: Heterospory and evolution of seed habit

i) Isopory to Heterospory

ii)Megasporangium to ovule and seed (Archeosperma, Elkinsia, and Morentia).

Palaeozoic Gymnosperm:- Plants with fern like leaves .

i) Pteridosperms:-

a) Lyginopteridales:Lyginopteridaceae, Medullosaceae,

b)Cycadeoidales-Cycadeoidaceae, Williamsoniaceae,

c) Cycad foliage (*Nilssonia*, *Baenia*).

Module II

More Diversification in Primitive Gymnosperm: Cordaitales, Glossopteridales, Pentoxylales, General characters of Coniferales (Voltziaceae represented by *Ulrichia*) Caytoniales, and phylogenetic consideration of all the orders.

Module III

Study of Deccan Intertrappean flora of India. Formation of Deccan traps and Intertraps, age and its floristic composition in relation to Pteridophytes (*Azolla*, *Salvinia*, *Surangea*), Gymnosperms (*Mohgaostrobus*, *Harrisostrobus*, *Takliostrobus*) and Angiosperms (*Palmoxylon*, *Palmocarpon*, *Triccocites*, *Enigmocarpon*, *Daberocarpon*, *Sahnianthus*, *Sahnipushpam*). Paleoclimate and Paleogeography of Deccan Intertraps.

Module IV

Paleopalynology-Important features of spores and pollen morphology, their role in stratigraphy and in exploration of coal and oil. Palaeopalynological studies, microfossils and its application. Paleoecology and paleogeography.

Indian Gondwana-Its stratigraphy and classification (Two fold and three fold). Index fossil.

*Note:-i) Different plant groups are to be studied with **key genera** for their morphology and anatomy of vegetative and reproductive parts

ii) Their evolutionary tendencies with origin should be highlighted

4T4 - Foundation Course II: Applied Botany

(Student shall opt for this paper from any other subject other than his/her main subject for post graduation)

Module I: Entrepreneurship in Botany

Concept, definition, structure and theories of entrepreneurship; Types of start-ups; Types of entrepreneurship, Entrepreneurship of NTFP (collection/Production, value addition, marketing strategies), Biodiesel/bio-ethanol plant production, *Trichoderma* production for control of soil borne fungi, honey production., Plant enzyme production

Module II: Green herbal techniques

Phytochemistry: Classification of secondary metabolites accumulated by the plants; extraction of phytochemicals

Plant based products: Techniques for extraction/preparation of various dyes, cosmetics, perfumes (essential oils), sweeteners (*Stevia* etc.), herbal medicine, nutraceuticals.

Fibre production: Coir, Jute, banana, cotton, silk cotton etc.

Cultivation of common medicinal herbs: *Aloe vera*, *Curcuma longa*, *Zingiber officinalis*, *Withania somnifera*, *Chlorophytum borivillanum*.

Module III: Gardening, silviculture and Post harvesting techniques

Gardening: History, types of gardens, landscape gardening, major gardens of the world.

Floriculture: General introduction, nursery management, methods of propagation (Bonsai, cutting, grafting, budding) poly house and green house, commercial floriculture.

Silviculture: Introduction, Agro-forestry, avenue trees, ornamental shrubs and trees cultivation.

Kitchen gardening: Spinach, tomato, brinjal, coriander, drumstick, lady's finger, chilly, curry leaf, methi and other spices etc.

Post harvest techniques: Vegetables, fruits, ornamentals, nutraceuticals,

Module IV: Culture techniques

Sterilization techniques for various types of cultures

Technique of- Mushroom culture, *Spirulina* cultivation, compost, vermi-composting, bio-fertilizer production, hydroponics, plant tissue culture, techniques to increase shelf-life of ornamental plants.

Suggested readings

Burch JG 1986. Entrepreneurship. Wiley, USA.

Desai R. 2013 Floriculture at glance. Kalyani Publ., New Delhi.

Desai V 1994. Forest management in India- Issues and Problems. Himalaya Publ. House, New Delhi.

Grewal HS and Singh P 2014. Landscape designing and ornamental plants. Kalyani Publ., New Delhi.

Gupta CB and Srinivasan NP 2001. Entrepreneurship in India. S. Chand and Sons, New Delhi.

Hartman HT, Kester DE, Davies FT(Jr) and Geneve RL 2002. Plant Propagation- Principles and Practices 6e. Prentice-Hall India, New Delhi.

Holt DH 1998. Entrepreneurship- New venture creation. Prentice-Hall of India, New Delhi.

Kas J. 1989. Entrepreneurship: Creativity and Organization. Prentice Hall Englewood Cliffs, New Jersey.

Kochhar SL 1998. Economic Botany in tropics 2e. Macmillan India Ltd., New Delhi.

Nandan H 2011. Fundamentals of Entrepreneurship 2e. PHI Learning Pvt. Ltd., New Delhi.

Randhwa GS and Mukhopadhyay A 1986. Floriculture in India. Allied Publ., New Delhi.

Sabnis SD and Daniel M 1990. A phytochemical approach to economic botany. Kalyani Publ., New Delhi.

Sagwal SS 2010. A textbook of silviculture. Kalyani Publ., New Delhi.

Sharma OP 1996 Hill's Economic Botany. TMH Publ. Co. Ltd., New Delhi.

Singh B. 2012. Horticulture at glance. Kalyani Publ., New Delhi.

Singh BD 2013. Plant Biotechnology. Kalyani Publ., New Delhi.

Swaminathan MS and Kochhar SL 2003. Groves of Beauty and Plenty- An atlas of major flowering trees in India. Macmillan India Ltd. New Delhi.

4T4 – Core :Plant Resources

Module 1: Economic Botany

Food plants: History, origin, distribution and nature

Morphology and anatomy of: Fiber yielding plants, forest resources (timber and non-timber plants), gum and resin yielding plants, fumitories and masticatories, spices and condiments

Food adulteration

Module 2: Pharmacognosy

Introduction, classification of crude drugs, plant anatomy (stomata, trichomes, xylem, phloem, ergastic substances)

Evaluation of drugs: organoleptic, microscopic, chemical, physical and biological

Drug adulteration

Module 3: Phytochemistry

Structure, classification, properties, importance and plant sources of: alkaloids, terpenoids, phenolics, steroids, glycosides

Module 4: Industrial Botany

Paper and pulp industry: Paper making, raw materials, manufacture of wood pulp, paper manufacture, kinds of paper and paper products.

Beverages: Source, plant description, cultivation, manufacturing, chemical composition- Tea Coffee and Cocoa.

Dyes: Plant sources (Description, chemical nature, extraction of dyes).

Essential oil: Occurrence, extraction, essential oils used in perfumery and other industries.

Rubber and latex: Classification of rubber, Natural rubber- source, cultivation, collection of latex, processing, uses of rubber

References

Sharma O P 1996 Hill's Economic Botany. TMH Publi., New Delhi.

Ali Mohammed 1998 Textbook of Pharmacognosy. CBS Publi., New Delhi.

Sabnis S D and Daniel M 1990 A Phytochemical approach to Economic Botany. Kalyani Publi., New Delhi.