

| Scheme | | | | | | | | | | | | | |
|---|--------------------|---|-----------------|-----------|----------|------------------|------------|----------|-----------|-----------------|------------|------------|--------------------------|
| M.Sc.– I Botany – Semester-I | | | | | | | | | | | | | |
| Subject | Course/ Paper Code | Paper Name | Teaching Scheme | | | Credits Assigned | | | | % of Assessment | | | |
| | | | Theor y | Pract. | Tut. | Theor y | Prac t. | Tut . | Total | CA | UA | Total | Min. Passing Marks |
| Core | 01MSCB 1 | General Microbiology, Phycology and Mycology | 4 | - | - | 3 | - | - | 3 | 20 | 80 | 100 | 40 |
| | 01MSCB 2 | Bryophytes & Pteridophytes | 4 | - | - | 3 | - | - | 3 | 20 | 80 | 100 | 40 |
| | 01MSCB 3 | Gymnosperm & Paleobotany | 4 | - | - | 3 | - | - | 3 | 20 | 80 | 100 | 40 |
| Elective PGMSCB 4 (Student Shall select any one from the elective group) | 01MSCB 4.1 | Molecular Biology and Plant Biotechnology-I | 4 | - | - | 3 | - | - | 3 | 20 | 80 | 100 | 40 |
| | 01MSCB 4.2 | Reproductive Biology of Angiosperms-I | | | | | | | | | | | |
| | 01MSCB 4.3 | Paleobotany-I | | | | | | | | | | | |
| | 01MSCB 4.4 | AdvancePhycology-I | | | | | | | | | | | |
| | 01MSCB 4.5 | Mycology and Plant Pathology -I | | | | | | | | | | | |
| RM | 01MSCB 5 | ResearchMethodology | 5 | - | - | 4 | 0 | - | 4 | 20 | 80 | 100 | 40 |
| Practical-I | 01MSCB 6 | Based on 01MSCB 1 & 01MSCB 2 | - | 5 | - | - | 2 | - | 2 | 25 | 75 | 100 | 50 |
| Practical-II | 01MSCB 7 | Based on 01MSCB 3 & 01MSCB 4 | - | 5 | - | - | 2 | - | 2 | 25 | 75 | 100 | 50 |
| Total | | | 19 | 10 | - | 16 | 4 | - | 20 | 150 | 550 | 700 | 300 |

M.Sc.– I Botany – Semester-II

| Subject | Course/Paper Code | Paper Name | Teaching Scheme | | | Credits Assigned | | | | % of Assessment | | | |
|---|-------------------|---|-----------------|-----------|----------|------------------|----------|----------|-----------|-----------------|------------|------------|--------------------|
| | | | Theory | Pract. | Tut. | Theory | Pract. | Tut. | Total | CA | UA | Total | Min. Passing Marks |
| (Major) Mandatory | 02MSCB 1 | Plant Physiology | 4 | - | - | 3 | - | - | 3 | 20 | 80 | 100 | 40 |
| | 02MSCB 2 | Plant Development & Embryology | 4 | - | - | 3 | - | - | 3 | 20 | 80 | 100 | 40 |
| | 02MSCB 3 | Angiosperm-I | 4 | - | - | 3 | - | - | 3 | 20 | 80 | 100 | 40 |
| Elective 02MSCB 4 (Student Shall select any one from the elective group) | 02MSCB 4.1 | Molecular Biology and Plant Biotechnology-II | 4 | - | - | 3 | - | - | 3 | 20 | 80 | 100 | 40 |
| | 02MSCB 4.2 | Reproductive Biology of Angiosperms-II | | | | | | | | | | | |
| | 02MSCB 4.3 | Paleobotany-II | | | | | | | | | | | |
| | 02MSCB 4.4 | Advance Phycology- II | | | | | | | | | | | |
| | 02MSCB 4.5 | Mycology and Plant Pathology -II | | | | | | | | | | | |
| OJT/FP | 02MSCB 5 | On Job Training | - | 5 | - | - | 4 | - | 4 | 20 | 80 | 100 | 40 |
| Practical-I | 02MSCB 6 | Based on 02MSCB 1 & 02MSCB 2 | - | 4 | - | - | 2 | - | 2 | 25 | 75 | 100 | 50 |
| Practical-II | 02MSCB 7 | Based on 02MSCB 3 & 02MSCB 4 | - | 4 | - | - | 2 | - | 2 | 25 | 75 | 100 | 50 |
| Total | | | 16 | 13 | - | 12 | 8 | - | 20 | 150 | 550 | 700 | 300 |

Note: As per GR, there is no mention of Ability Enhancement Course in the skeleton of PG syllabus for NEP20.

GONDWANA UNIVERSITY, GADCHIROLI

(According to NEP- 2020)

SYLLABUS

For

M. Sc.

BOTANY

SEMESTER I & II

Under

Choice Based Credit System

(CBCS)

शासन निर्णय क्रमांक: एनईपी-2022/प्र. क्र. ०९/विशि-३शिकाना दिनांक
१६.०५.२०२३सोबतचे

परिशिष्ट

Structure and Credit Distribution of PG Degree Program

Vide G.R. No. NEP-2022 /CR No. 09/VISHI-3 /शिकाना dated April 20, 2023, the Directive, covering the Credit distribution structure for Four Year UG Honours/ Honours with Research Degree Programme with Multiple Entry and Exit options, was issued. In continuation of Section 8 of this GR- 'Design of PG / Master's Programmes', the illustrative Table depicting the Credit Distribution for Two Year PG Programme with one Exit Option/ One Year PG Programme is as given below:

Illustrative Credit distribution structure for Two Years/ One Year PG (M. A./M. Sc./M. Com.) and Ph. D. Programme

| Year (2Yr PG) | Level | Sem. (2Yr) | Major | | RM | OJT / FP | RP | Cum. Cr. | Degree |
|---|-------|---------------|--------------------------------|-----------|---|-------------|------------------------|-------------|--|
| | | | Mandatory | Electives | | | | | |
| I | 6.0 | Sem I | 12-14 (2*4+2*2 Or 3*4+2) | 4 | 4 | | | 20-22 | PG Diploma (after 3Yr Degree) |
| | | Sem II | 12-14 (2*4+2*2 Or 3*4+2) | 4 | | 4 | | 20-22 | |
| Cum. Cr. For PG Diploma | | | 24-28 | 8 | 4 | 4 | - | 40-44 | |
| Exit option: PG Diploma (40-44 Credits) after Three Year UG Degree | | | | | | | | | |
| II | 6.5 | Sem III | 12-14 (2*4+2*2 Or 3*4+2) | 4 | | | 4 | 20-22 | PG Degree After 3- Yr UG Or PG Degree after 4- Yr UG |
| | | Sem IV | 10-12 (2*4+2 or 3*4) | 4 | | | 6 | 20-22 | |
| Cum. Cr. for 1 Yr PG Degree | | | 22-26 | 8 | | | 10 | 40-44 | |
| Cum. Cr. for 2 Yr PG Degree | | | 46-54 | 16 | 4 | 4 | 10 | 80-88 | |
| 2 Years -4 Sem. PG Degree (80-88 credits) after Three Year UG Degree or 1 Year-2 Sem PG Degree (40-44 credits) after Four Year UG Degree | | | | | | | | | |
| | 8.0 | | Course Work Min. 12 (3*4) | | Training in Teaching /Education/ Pedagogy: 4 | | 16 + Ph. D. Work | | Ph.D.in Subject |

Abbreviations: Yr.: Year; Sem.: Semester; OJT: On Job Training: Internship/
Apprenticeship; FP: Field projects; RM: Research Methodology; Research
Project: RP; Cumulative Credits: Cum. Cr.

शासन निर्णय क्रमांक: एनईपी-2022/प्र. क्र. ०९/विशि-३शिकाना

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- (a) With effect from Academic Year 2023-24, Two years Master's Degree Program will be revamped as per the Illustrative Credit Distribution given in the above Table.
- (b) Credits offered per Semester will be a Minimum of 20 and a Maximum of 22. While minimum credits are mandatory as per National Credit Framework, the Universities can evolve the mechanism for providing Semester/ Levelwise credit attainment flexibility within the broad framework.
- (c) Under the One-year PG Diploma program, and two-year master's Degree program, the students must complete on-the-job training/internship of 04 credits during summer break, after completion of the second semester of the first year in the respective Major Subject.
- (d) The 4 Credits Research Methodology Component is mandatory in the First Year.
- (e) Since the Master's Programme is based on DSC Specialisation, the PG curricular framework will not include Minor Subject. Electives selected in the PG program may be Relevant to OR Supportive of the Major Subject chosen. The Statutory authorities of the University or Autonomous College can take a decision in this regard.
- (f) The students will have to undertake a research project of 4 credits in Semester III and a research project of 6 credits in Semester IV in the second year of the two-year master's degree program. This is also applicable to the students admitted to one year PG program after completion of four years UG Program.
- (g) Colleges already having permission and recognition for the PG degree programme along with UG degree programme in the same Major shall be automatically allowed to continue PG degree programme in the same Major without undergoing any additional procedures. Similarly, the colleges with approved PG programme and Ph.D. Research Centre in the same Major shall be automatically allowed to continue PG and Ph. D. Degree programme without undergoing any additional procedures.
- (h) The exit option at the end of one year of the Master's degree program will commence from AY 2024-25. Students who have joined a two-year Master's degree program may opt for exit at the end of the first year and earn a PG Diploma.
- (i) The PG Diploma may be awarded to a student provided they have earned the requisite credits in one year including on-the-job training of 04 credits during summer break, after completion of the second semester of the first year in the respective Major Subject.

शासन निर्णय क्रमांक: एनईपी-2022/प्र. क्र. ०९/विशि-३शिकाना

- (j) The one-year Master's Degree Program will begin with effect from Academic Year 2027-28.
- (k) Re-entry to complete the PG degree, after taking the exit option, will be permissible up to 05 years from the date of admission to the PG program.
- (l) With regards to the Eligibility criteria and Procedure for admission to the Ph.D. Programme, Duration of the Ph.D. Programme, Eligibility and Allocation of Research Supervisor, Course Work (Credit requirements, number, duration, syllabus, minimum standards for completion), Research Advisory Committee and its Functions, Academic, research, administrative, and infrastructure requirements to be fulfilled by Colleges for getting recognition for offering Ph.D. Programme, Award of Ph. D. Degree etc, the Universities and Autonomous Colleges must comply UGC (Minimum Standards and Procedure for Award of Ph.D. Degree) Regulations, 2022, dated Nov. 7, 2022.
- (m) The University and Autonomous College must adopt this GR within 10 days after its issue.

| M. Sc. Botany Semester I & II for the Year 2023-24 | | | | |
|---|--|----------------|---|----------------|
| | Semester-I | Credits | Semester-II | Credits |
| Major (DSC) | Paper I: General Microbiology, Phycology and Mycology | 04 | Paper V: Plant Physiology | 04 |
| | Paper II: Bryophytes & Pteridophytes | 04 | Paper VI: Plant Development & Embryology | 04 |
| | Paper III: Gymnosperm & Paleobotany | 04 | Paper VII: Angiosperm - I | 04 |
| Major Elective (DSE) | i) Molecular Biology and Plant Biotechnology – I ii) Reproductive Biology of Angiosperms - I iii) Paleobotany – I iv) Advanced Phycology-I v) Palynology-I Any one from mentioned above per affiliated College | 04 | i) Molecular Biology and Plant Biotechnology – II ii) Reproductive Biology of Angiosperms - II iii) Paleobotany – II iv) Advanced Phycology-II v) Palynology-II Any one from mentioned above per affiliated College | 04 |
| Minor | 1. Research Methodology | 04 | 2. OJT/FP | 04 |

| M. Sc. Botany Semester III & IV for the Year 2023-24 | | | | |
|---|--|----------------|--|----------------|
| | Semester-III | Credits | Semester-IV | Credits |
| Major (DSC) | Paper VII: Angiosperms - II | 04 | Paper X: Plant Ecology | 04 |
| | Paper VIII: Cytology and Genetics | 04 | Paper XI: Plant Biotechnology | 04 |
| | Paper IX: Plant Biochemistry | 04 | Paper XII: Plant Breeding, Biostatistics and Biosafety | 04 |
| Major Elective (DSE) | i) Molecular Biology and Plant Biotechnology – III ii) Reproductive Biology of Angiosperms - III iii) Paleobotany – III IV) Advanced Phycology-III V) Palynology-III <i>Any one from mentioned above per affiliated College</i> | 04 | i) Molecular Biology and Plant Biotechnology – IV ii) Reproductive Biology of Angiosperms - IV iii) Paleobotany – IV IV) Advanced Phycology-III V) Palynology-IV <i>Any one from mentioned above per affiliated College</i> | 04 |
| Minor | 1. Research Methodology | 04 | 2. OJT/FP | 04 |

Semester I -Major (DSC)

PAPER –I: General Microbiology, Phycology and Mycology

Course code- PSCBOTT01 Credit - 04

UNIT – I

General Microbiology: Definition and Scope.

Historical perspective: Contributions made by Leeuwenhoek, Pasteur, Robert Hook, Jenner, Waksman, Iwanowsky. Koch's Postulate.

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

Archaeobacteria and Eubacteria: General account; ultrastructure, morphology, nutrition and reproduction and economic importance.

Cyanobacteria: General account, ultrastructure and reproduction in major forms (*Microcystis*, *Lyngbya*, *Nostoc*, *Scytonema*, *Gloeotrichia*, *Stigonema*) and economic importance.

UNIT - II

Phycology: Definition and Scope.

Contributions of Indian Phycologists: M. O. P. Iyenger, V. D. Chauhan, C. Mervin Palmer and Vasudeva Krishnamurthy.

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

Algae in diversified habitats: Terrestrial, Freshwater, Marine algae, their thallus organization; cell ultrastructure and reproduction (vegetative, asexual, sexual).

Algal blooms; algal biofertilizers; algae as a food, feed and other uses in industry.

UNIT –III

Mycology: Definition and Scope.

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: *Synchytrium*, *Phytophthora*, *Peronospora*,
ii. Zygomycetes: *Mucor*, *Rhizopus*,

UNIT – IV

Comparative study, classification and evolutionary trends in the following:

iii. Ascomycetes: *Saccharomyces*, *Phyllactinia*, *Chaetomium*, *Xylaria*

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

v. Deuteromycetes: *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.)

Laboratory Exercises:

Different staining techniques in Microbiology:

Differential stain (Gram staining), Endospore stain, Acid Fast Stain, Metachromatic Granule stain, Flagella stain.

Classification and study of the following classes:

Cyanobacteria: *Microcystis*, *Lyngbya*, *Nostoc*, *Scytonema* and *Gloeotrichia*

Chlorophyta: *Pandorina*, *Eudorina*, *Stigeoclonium*, *Ulva*, *Chlorella*, *Scenedesmus*, *Caulerpa*, *Valonia*, *Acetabularia*.

Phaeophyta: *Spacelaria*, *Padina*, , *Turbinaria*.

Rhodophyta: *Gelidium*, *Gracilaria*, *Polysiphonia*.

Euglenophyta: *Euglena*

Bacillariophyta: *Cyclotella*, *Synedra*, *Cymbella*, *Navicula*, *Gomphonema*.

Preparation and Identification of Algal cultures (Any 5)

Spirogyra, *Cosmarium*, *Cymbella*, *Mougeotia*, *Oscillatoria*, *Spirulina*, *Chlorella*, *Phormidium*, *Pithophora*, *Oedogonium*, *Chara*, *Nitella*, *Lyngbya*.

Morphological Studies of Fungi (any 12 of the following genera)

Stemonitites, *Perenospora*, *Phytophthora*, *Albugo*, *Mucor*, *Rhizopus*, *Yeast*, *Aspergillus*, *Penicillium*, *Chaetomium*, *Taphrina*, *Peziza*, *Erysiphe*, *Phyllactenia*, *Uncinula*, , *Melamosora*, *Uromyces*, *Ustilago*, *Polyporus*, *Morchella*, *Alternaria*, *Helminthosporium*, *Colletotrichum*, *Plasmodiophora*, *Cercospora*, *Fusarium*, *Claviceps*.

Symptomology of some diseased plants (any 5 of the following symptoms).

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.

Preparation and Identification of Fungal cultures (Any 5)

Rhizopus, *Mucor*, *Aspergillus*, *Penicillium*, *Curvularia*. *Colletotrichum*, *Alternaria*, *Helminthosporium*.

Field study: For collection and studying Algal, fungal flora and plant pathology specimens.

Preparation of (Classical/Digital) Herbarium.

Submission of Field/Excursion/Institution visit report.

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. Online Journals available on UGC –VSAT.

M. Sc. Botany Syllabus
Semester I -Major (DSC)
PAPER –II: Bryophytes & Pteridophytes

Course code- PSCBOTT02

Credit - 04

UNIT - I

General characters, distribution, classification, ecology of Bryophytes, Bryophytes as ecological indicators, morphogenesis in bryophytes, fossil history of bryophytes, cytology of Bryophytes, regeneration in bryophytes, modern trends in taxonomy.

Contributions of Indian Bryologist (Prof. Shiv Ram Kashyap, Prof. S. K. Pande and Prof. Ram Udar).

UNIT - II

General account on –

Hepaticopsida: Sphaerocarpales, Takakiales,

Anthocerotopsida: Anthocerotales,

Bryopsida: Sphagnales, Polytrichales.

UNIT - III

General characters, distribution and classification of Pteridophytes.

Evolution of stele, heterospory and seed habit, apospory and apogamy in Pteridophytes.

Contributions made of Indian Pteridologists (Prof. S. S. Bir, Prof. B. K. Nayar, Prof. Pran Nath Mehra, Prof S. C. Verma, Prof S. S. Khullar and Prof. S. C. Srivastava).

General account on –

Ryniopsida, Psilopsida, Lycopside (Protolepidodendrales, Lycopodiales, Selaginiales, Isoetales).

UNIT - IV

General account of Sphenopsida (Hyeniales, Equisetales), Filicopsida (Ophioglossales, Filicales, Salviniaceae, Marsileales), Tracheophyta (Progymnospermosida).

Laboratory Exercises:-

BRYOPHYTES:

Study of morphological and reproductive characters of representative members mentioned in the syllabus using clear 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:

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 slide is compulsory.

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) 13
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*. 9
10. Cavers, F. (1911). *The interrelationship of Bryophyta VII-IX.* *New Phytologist*. 10.
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
i. (*Chronica Botanica*)
19. Kashyap S.R. (1933). *Liverworts of the western Himalayas and The Punjab Plain*2
i. (*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 Embriyophyta, Bryophyta* (Centaral 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. PuriPrem (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 (VikasPubl House Pvt Ltd.)
- Schuster R. (1966). The Hepaticae and Anthocerotae of North America. East of the Hundredth meridian, Newyork (Colombia University Press).
29. 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.)
30. 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
31. Smith G. M. (1955). Cryptogamic Botany-vol. 2 Bryophyta and Pteridophyta (McGraw Hill Book compony, Newyork)
32. Smith W. N. and G. W. Rothwell (1993). Paleobotany and the evolution of plants (Cambridge Univ. press)
33. Sporne K.R. (1962) The morphology of pteridophyta (Hutchinson Univ. Library, London)
34. Steil W.N. (1939) Apogamy, Apospory and Parthenogenesis in the pteridophyta, Bot. rev, 5, 433-453.
35. Steward W.N. (1983) Paleobotany and the evolution of plants. 1st ed. New York, (Cambridge Univ. press)
36. Surange K.R and S. Chandra (1972) Fructification of Glossipteridae from India, Paleobotanist 21, 1-17.
37. Taylor T.N. (1988) the origin of land plants- Some answers more questions, Taxon, 37, 805-33.
38. UdarRam (1970) An introduction to bryophyte (ShashidharmalviyaPrakashan, Lucknow)
39. Udar Ram, Srivastava S.C. and Kumar Dinesh (1970) Genus Buxbaumia in India, Curr. Sci. (India) 39, 14-15.
40. Walton J. (1925) Carboniferous Bryophyta I. Hepaticae. Annals of Botany, 39, 563-72.
41. Walton J. (1928) Carboniferous Bryophyta II. Hepaticae&Musci. Annals of Botany, 42, 707-16.
42. Walton J. (1940) An introduction to the study of fossil plants. A& C Black, London.
43. Watson E.V. (1967) The structure and life of Bryophytes, 2nd ed, London, Hutchinson.
44. Wilson C.W. (1942) Thetelome theory and the origin of the stamen. Am. J Bot., 29, 759-764. Zimmermann W. (1952) Main results of the "Telome theory". The Paleobotanist, Birbal Sahni Memorial Volume, 456-70.
45. Panigrahi, G. (2003). Taxonomy and Biogeography of Indian Pteridophytes. In: Chandra, S., Srivastava, M. (eds) Pteridology in the New Millennium. Springer, Dordrecht. https://doi.org/10.1007/978-94-017-2811-9_3
46. Chandra, S. (2003). Professor Bala Krishnan Nayar: A Biographical Sketch. In: Chandra, S.,Srivastava, M. (eds) Pteridology in the New Millennium. Springer, Dordrecht. https://doi.org/10.1007/978-94-017-2811-9_1
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50. Srivastava, S. C., Chakraborty, D., and Alam, A. 2015. Bryology in India - Retrospect and Prospects. Plant Science Today 2(4): 123-125.
51. AFROZ ALAM (2014)Professor S. C. Srivastava- A Living Legend of Indian Bryology .Frahmia. 9 ISSN 2199-4897
52. Rawat, K. K., Verma, P. K. and Alam, A. 2015. Nomenclatural updates in Kashyap's 'Liverwort flora of western Himalayas and Panjab Plains'. Plant Science Today 2(4): 179-183.
53. <http://dx.doi.org/10.14719/pst.2015.2.4.146>
54. <https://www.ias.ac.in/article/fulltext/secb/005/06/0333-0337>
55. <https://plants.jstor.org/stable/10.5555/al.ap.person.bm000375976>
56. <https://sites.google.com/site/efloraofindia/publications/publications/s-p-khullar>
57. http://www.insa.ndl.iitkgp.ac.in/xmlui/bitstream/handle/1234567/281/BM24_0402.pdf?sequence=1&isAllowed=y
58. <https://www.theindiapost.com/education/prof-sp-khullar-elected-president-indian-science-congress/>

Semester I -Major (DSC)

Paper –III: Gymnosperms and Paleobotany

Course Code- PSCBOTT03

Credit - 04

UNIT - I – Gymnosperms: General Characteristics; Systems of Classification; Economic Importance. Distribution of Gymnosperms in India. Progymnospermopsida- *Aneurophyton*, *Archaeopteris*

Comparative morphology and evolutionary tendencies of-

1. Pteridospermales – Lyginopteridaceae (*Lyginopteris* /*Calymatotheca hoeninghausii*)
2. Medullosaceae- *Medullosa*

UNIT - II

3. Glossopteridales- *Glossopteris*
4. Caytoniales- *Caytonia*
5. Cycadeoidales – Williamsoniaceae- *Williamsonia*, Cycadeoidaceae-*Cycadeoidea*.
6. Pentoxylales- *Pentoxylon*
7. Cycadales – Cycadaceae- *Cycas*

UNIT - III

8. Cordaitales- *Cordaites*
9. Coniferales – *Pinus*
10. Taxales – *Taxus*
11. Ginkgoales – *Ginkgo*
12. Gnetales- *Gnetum*

UNIT - IV – Paleobotany

Introduction : Plant fossils – Fossilization, Condition for Fossilization, Types of Fossil, Techniques for Fossil study, Reconstruction and Nomenclature; Age Determination; Geological Time Scale; Objectives of Paleobotany; Informations regarding different Fossil Parks and Museum of India; Birbal Sahni Institute of Paleobotany, Lucknow.

Laboratory Exercises:

1. Study of Progymnospermopsida- *Aneurophyton*, *Archaeopteris*
2. Comparative Study of vegetative and reproductive parts of –
Cycas, *Pinus*, *Taxus*, *Ginkgo*, *Gnetum*
3. Study of important fossil gymnosperms from material and permanent slides.

4. Study of different types of Fossils.
5. Study of different Fossil Parks and Museum of India;
6. Visit to Palaeobotanical Institutes, localities and collection of specimens.
7. Field visits to ecologically different localities to study living gymnosperms.

Suggested Readings:

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 Fransisco.
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. On line Journals available on UGC -VSAT

M. Sc. Botany Syllabus

Semester I - Paper:IV (Major Elective - DSE)

Molecular Biology and Plant Biotechnology – I

Unit I

Cell wall: Structure; functions; biogenesis and growth; cell differentiation.

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

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

Unit II

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

Cellular organelles: Ultra-structure and functions of Golgi complex, Lysosomes, Peroxisomes, Endoplasmic reticulum, Mitochondria, Chloroplast and plant Vacuoles.

Unit III

Nucleus: Ultra-structure and functions; nuclear pores; nucleolus.

Nucleic acids: forms of DNA, RNA – structures; conformations; functions.

DNA replication: Machinery and mechanism in prokaryotes and eukaryotes; DNA damage and repair.

Unit IV

Techniques in Cell Biology: Principle and applications of Cell fractionation techniques, confocal microscopy, Electron microscopy, Flow cytometry.

Techniques in Molecular Biology: Principle and applications of Spectroscopy - UV-Visible; IR; CD-ORD; Atomic Absorption; Flame; NMR, Chromatography – Ion-Exchange; Gel Filtration; Affinity; Partition and adsorption, Radioactive Active Tracer Technique, Fluorescence Microscopy, Electrophoresis – Capillary; Gel; Isoelectric focusing, 2-D gel; Affinity; Pulsed-Field; Electro-blotting, Immuno-techniques – RIA; ELISA, FISH, GISH.

Suggested Readings:

1. Atherly, A.G., Griton, J.R. and Mc Donald, J. F. 1999. The Science of Genetics. Saunders College Pub. Fort Worth, USA.
2. Buchanan, B.B., Gruissem, W. and Jones, R. L. 2000 Biochemistry and Molecular Biology of Plants. American Soc. Of Plant Physiologists, Maryland, USA.
3. Bush, H. Rothblum, L. 1982. Vol. X. The Cell Nucleus RDNA part A. Academic Press.
4. Dc, D. N. 2000 Plant cell vacuoles: An introduction. CSIRO Publication, Collingwood, Australia.
5. De Robertis, E.D.P. and De Robertis, E.M.F. Cell and Molecular Biology 8th Ed. B. I. Waverly Pvt. Ltd., New Delhi.
6. Karp, G. 1999 Cells and Molecular Biology; Concepts and Experiments. John Wiley & Sons, Inc., USA.

7. 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
8. 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
9. Russel, P. J. 1998 Genetics (5th Edi.) The Benjamin/ Cummings Publishing Com. Inc., USA
10. Wolf, S.L. 1993. Molecular and Cellular Biology, Wadsworth Publishing Co., California, USA

Practical:

1. Cell organization and cellular structure study.
2. Cell fractionation & isolation of Chloroplast and mitochondria.
3. Demonstration of vital structure and functions of cell organelles.
4. To perform flagella staining.
5. Preparation of Buffer stocks (TBE, TE, TAE, PBS etc.).
6. Isolation of plant DNA and its quantification by spectrophotometric method.
7. Quantification of DNA by Diphenyl Amine Reagent method.
8. Isolation of DNA and preparation of Cot-curve.
9. Isolation and quantification of RNA by Orcein method.
10. Isolation of Proteins and its quantification.
11. Demonstration of Chromatography (Ion-Exchange; Gel Filtration; Affinity; Partition and adsorption).
12. Demonstration of Agarose gel Electrophoresis
13. Demonstration of Polyacrylamide Gel Electrophoresis (PAGE).
14. Demonstration of 2-D electrophoresis.
15. Demonstration of Blotting Techniques (Southern; Northern; Western).
16. Demonstration of Immuno-techniques (Dot-ELISA; RIA; Ouchterlony Double Diffusion Assay).

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
- Cell Biology International
- Cell Death and Differentiation
- Cell Motility and the Cytoskeleton
- Cellular Physiology and Biochemistry
- Current Advances in Plant Sciences
- Cytokine
- 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 Science

M. Sc. Botany Syllabus
Semester I - Paper:IV (Major Elective - DSE)
Reproductive Biology of Angiosperms - I

Unit 1:

Introduction and scope of Reproductive Biology.

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

Contributions of G.B. Amici, W. Hofmeister, E. Strasburger, S.G. Nawaschin, P. Maheshwari, B.M. Johri, W.A. Jensen, J. Heslop-Harrison, H.Y. Mohan Ram.

Embryological Features of Taxonomic Importance, Role of embryology in taxonomy.

Reproduction in angiosperms: Types of reproduction, Vegetative reproduction (natural and artificial) and sexual reproduction, The Life cycle of an Angiosperm.

Unit 2:

Flower Development: Rise of Flowering plants, Evolution of Flower, Development of Flower in Angiosperms, Basic structure of Flower, floral organ differentiation.

The flower: A modified shoot, parts of flower (types and modification in Bracts, Calyx. Corolla, Androecium, Cohesion of stamens, Adhesion of stamens, Gynoecium, Placentation) Types of Flowers (On the basis of sex organs present, symmetry, Position of floral leaves and presence of Accessory whorls). Floral formula and floral diagram

Unit 3:

Sex determination in flowering plants: bisexual and unisexual flowers, regulation of unisexuality, genetic regulation of monoecy, genetics of sexuality in dioecious plants (1. Active-y system of sex determination and 2. X-to- autosome balance system of sex determination) hormonal regulation of sexuality, evolution of sexual dimorphisms in plants.

Inflorescence: Types of inflorescence, Special types and its significance.

Unit 4:

Anther: Development of anther (microsporangium), Structure, anther wall, endothecium, middle layer, tapetum-Structure, types-structure 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.

Unique features: Pseudomonads, polyads, massulae, pollinia, pollen embryo sacs.

Practicals Major

1. To study and identify different types of inflorescences.
2. To study and identify different types of Flower
3. To study and identify parts of Flower - Androecium: i) Anther filament relationship
ii) Cohesion of stamens and iii) Adhesion of stamens iv) Length of filament. (as per theory syllabus).
4. To study different placentation types. (Slides/photographs/fresh material).
5. Study of mitosis and meiosis and identification of various stages. (slides/photographs/fresh material).
6. To study various vegetative reproductive organs.
7. To study various artificial vegetative propagation 1. Root cutting 2. Stem cutting 3. Leaf cutting
8. To study artificial grafting method and its types.
9. To study floral diagram of various flowers (Locally available)
10. To study Structure of anther, microsporogenesis and pollen grain (slides/photographs/fresh material).
11. Anther: Wall and its ontogeny; Tapetum (amoeboid and glandular); MMC, spore tetrads, uninucleate, bicelled and dehisced anther stages through slides/micrographs.

Practicals Minor

1. To dissect the given flowers and study of reproductive organs
2. To study special types of inflorescence.
3. To dissect the flower and study the structure of Pollinia in given plants.
4. To study the symmetry of flowers.
5. To study the floral formula of various flowers (Locally available)
6. Preparation of dissected whole mounts of endothecium, tapetum and endosperm.
7. Quash preparations of tapetum, microspore mother cells, dyads, tetrads pollinia and massulae.
8. Sketching of anther wall with the help of camera lucida.
9. To study the different modification of Calyx.

Suggested Readings:

Alex Harkess , Jim Leebens-Mack, A Century of Sex Determination in Flowering Plants, *Journal of Heredity*, Volume 108, Issue 1, 1 January 2017, Pages 69–77, <https://doi.org/10.1093/jhered/esw060>

Bendre A. and Pande P. C. *Introductory Botany*. 2nd Edition. Rastogi Publication .Meerut ,India.

Bhandari N. N. 1984, *The microsporangium in embryology of angiosperms* (ed B.M. Johri) Springer- Verlag, Berlin, pp. 53-121

Bhandari N. N. 1984, *The microsporangium in embryology of angiosperms* (ed B.M. Johri) Springer- Verlag, Berlin, pp. 53-121.

Bhojwani S.S/Bhatnagar S.P. & Dantu P.K. 2015. *The Embryology of Angiosperms*, 6th Edition Front Cover Vikas Publishing House.

Bhojwani, S.S. and Bhatnagar, S.P. 2000. *The Embryology of Angiosperms*. Vikas Publishing House, Delhi.

Brien E. S. And Gunning F.R.S. 2000. JOHN HESLOP-HARRISON 10 February 1920 — 7 May 1998. *Biog. Mems Fell. R. Soc. Lond.* 46, 197–217.

<https://royalsocietypublishing.org/doi/pdf/10.1098/rsbm.1999.0080> Britannica, T. Editors of Encyclopaedia (2023, May 14). Eduard Adolf Strasburger. *Encyclopedia Britannica*. <https://www.britannica.com/biography/Eduard-Adolf-Strasburger>.

Byng James W. 2014. *The Flowering Plants Handbook* Edition: 1st Publisher: Plant Gateway Ltd. ISBN: 978-0-9929993-0-8. DOI: 10.13140/2.1.1849.8566.

Dellaporta S L , A Calderon-Urrea, Sex determination in flowering plants., *The Plant Cell*, Volume 5, Issue 10, October 1993, Pages 1241–1251, <https://doi.org/10.1105/tpc.5.10.1241>

Donald McEwan Alexander and William J. Lewis. 2009. *Series Grafting and Budding Edition 2. A Practical Guide for Fruit and Nut Plants and Ornamentals* LANDLINKS PRESS.

F. Palermo, 1870. Sulla vita e le opere di Giovanni Battista Amici, “*Bullettino di bibliografia e di storia delle scienze matematiche e fisiche*”, tomo III, Roma (A biography of Giovanni Battista Amici. https://www.arcetri.inaf.it/gbamici/eng/biografia/biografia_pt9.htm)

Gardner Frank Easter 1932. *The Vegetative Propagation of Plants*. University of Maryland, Agricultural Experiment Station.

Gifford, E. M. and Foster A. S. 1988. *Morphology and Evolution of Vascular Plants*. W.H. Freeman & Company, New York.

Herr, J.M. (1984). *Embryology and Taxonomy*. In: Johri, B.M. (eds) *Embryology of Angiosperms*. Springer, Berlin, Heidelberg. https://doi.org/10.1007/978-3-642-69302-1_14

Horner Jack and Horner Harry 2014. In Memorium: William A. Jensen, 1927-2014 .
Genetics, Development and Cell Biology
(<https://dr.lib.iastate.edu/server/api/core/bitstreams/a57fd4a3-1ae8-4b75-a23d-974014e50912/content>)

HU Shi-Yi. Centenary on S.G.Nawaschin's Discovery of Double Fertilization: Retrospects and Prospects[J]. *J Integr Plant Biol.*, 1998, 40(1).1-13.

Johri, B. M., & Rao, P. S. (1984). Experimental Embryology. *Embryology of Angiosperms*, 735–802. doi:10.1007/978-3-642-69302-1_16

Johri, B. M., Srivastava, P. S., & Singh, N. (2001). Reproductive Biology of Angiosperms. *Reproductive Biology of Plants*, 237–272. doi:10.1007/978-3-642-50133-3_11

Johri, B.M. (1984). *Embryology of Angiosperms*; Editors · Brij Mohan Johri ; DOI · ; Publisher · Springer Berlin, Heidelberg. <https://doi.org/10.1007/978-3-642-69302-1>

Johri, B.M., Ambegaokar, K.B. (1984). *Embryology: Then and Now*. In: Johri, B.M. (eds) *Embryology of Angiosperms*. Springer, Berlin, Heidelberg.

Johri, B.M., Ambegaokar, K.B. (1984). *Embryology: Then and Now*. In: Johri, B.M. (eds) *Embryology of Angiosperms*. Springer, Berlin, Heidelberg. https://doi.org/10.1007/978-3-642-69302-1_1

Johri, B.M., Ambegaokar, K.B. (1984). *Embryology: Then and Now*. In: Johri, B.M. (eds) *Embryology of Angiosperms*. Springer, Berlin, Heidelberg. https://doi.org/10.1007/978-3-642-69302-1_1

Kaplan, D. R., & Cooke, T. J. (1996). The Genius of Wilhelm Hofmeister: The Origin of Causal-Analytical Research in Plant Development. *American Journal of Botany*, 83(12), 1647–1660. <https://doi.org/10.2307/2445841>

Lersten Nels R. 2008. *Flowering Plant Embryology: With Emphasis on Economic Species*, John Wiley & Sons.

Maheshwari, P. , 1950. *An Introduction to Embryology of Angiosperms*. Tata McGraw Hill Publishing Co. , New Delhi

Maheshwari, R., Shivanna, K. R., Swamy, R. D., Rao, K. S., & Mathur, G. (2014). A doyen of Indian botanists: H. Y. Mohan Ram. *Current Science*, 106(2), 305–309.

Martin Cyrus 2017. Wilhelm Hofmeister and the foundations of plant science. *Current Biology* Volume 27, Issue 17, Pages R853-R855.

Mohan Ram H.Y.2003. Brij Mohan Johari, *Current Science*, Vol. 85, No. 01.100-101.

Rao, I.U., Mohan Ram, H.Y. 1985. Floral differentiation and its modification. *Proc. Indian Acad. Sci.* 94, 525–537 . <https://doi.org/10.1007/BF03053164>

Sharma H. P. 2009. Plant Embryology: Classical and Experimental Alpha Science International.

Shivanna K. R. 2018. H. Y. Mohan Ram (1930–2018). Current Science Vol. 115, No. 1, pp. 168-171

Shivanna K. R. and Mohan Ram H. Y. 2005. Contributions of Panchanan Maheshwari's school to angiosperm embryology through an integrative approach Current Science, Vol. 89, No. 11.1820-1834.

Takhtajan Armen 2009. Flowering Plants Springer Science & Business Media.

Volkman, D., Baluška, F. & Menzel, D. 2012. Eduard Strasburger (1844–1912): founder of modern plant cell biology. Protoplasma 249, 1163–1172 .

M. Sc. Botany Syllabus

Semester I – Paper-IV (Major Elective DSE)

Paleobotany – I

UNIT-I:

Study of Rhyniopsida (primitive vascular plants)-*Cooksonia*, *Hornioophyton*. Zosterophylopsida (ancestors of microphyllous plants)- *Zosterophyllum*, *Asteroxylon*. Lycopsidea (Hebaceous Lycopods of Devonian)– *Baragwanthia*, *Protolepidodendron*.

UNIT-II:

Sphenopsida- Origin and evolutionary consideration. Study of Hyeniales and Sphenophyllales. Horsetails and their relatives-Calamitales members. Filicopsida (Study of primitive ferns and their relatives)- Cladoxylales, Stauropteridales, Zygopteridales. Filicales- 1. Coenopteridales- *Ankyropteris*, 2. Marratiales-*Psaronius*.

UNIT-III:

Basic Geological information- Origin of the Earth; Present condition of the Earth; Life in Precambrian; Basic concepts of Continental Drift and Plate Tectonics. Concepts of Parataxon and Eutaxon, Indian fossil flora (The Lower, Middle & Upper Gondwana flora).

UNIT-IV:

Introduction to the science of Petrology- The earth zones, Chemical composition of earth crust, Classification of rocks (Igneous, Metamorphic and Sedimentary), Dating of rocks: relative dating by fossils, absolute dating (radiometry). Earth movements - Epirogenic, Orogenic and Cymatogenic., Tectonic features: Fold, Fault. Glaciations, volcanic eruption and earthquake.

Suggested Laboratory and Field Exercises

Major Exercises:

1. Ancestors of microphyllous plants- *Zosterophyllum*, *Asteroxylon*.
2. Herbaceous Lycopods of Devonian– *Baragwanthia*, *Protolpidodendron*.
3. Study of Sphenophyllales, Calamitales members.
4. Study of primitive ferns and their relatives Cladoxylales, Stauropteridales, Zygopteridales. Filicales- Coenopteridales-*Ankyropteris*, Marratiales - *Psaronius*
5. Study of different types of rocks.
6. Study of Tectonic features: Fold, Fault.

Minor Exercises:

7. Study of Rhyniopsida (Primitive vascular plants).
8. Study of the Earth Zones.

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. Meyen, S.V. (1987) – Fundamentals of Palaeobotany Chapman and Hill, London, New York.
4. Parihar, N.S. (1995) –Essentials of Palaeobotany, Central Book –Allahabad.
5. Stewart, W.N. & Rothwell, G.V. (1993) - Palaeobotany and Evolution of Plants, Cambridge Univ., Press-Cambridge.
6. Venkatchala, B.S. & Maheshwari, H.K. (1991) - Palaeobotanical Researches in India. Jour. Ind. Bot. Society-70; 1-12.
7. Wadia, D.N (1953) - Geology of India, Mac, Millan-Co. London.
8. Prasad, K.N. (1999) - An introduction to palaeobotany, APH Pub.
9. Cleal, J. Christopher. & B.A. Thomas (2009) - Introduction to Plant Fossils, Cambridge Univ., Press-Cambridge.
10. Willis, K. J. & Mc Elwain, J. C. (2014) - The Evolution of Plants (second edition) OXFORD University Press.
11. Stewart, W.N. and Rothwell G.W. (1993) - Palaeobotany and the Evolution of Plants, Cambridge University Press.

12. Arnold, C.A. (1947) - Introduction to Palaeobotany, Mc-Graw Hill Book Co. Inc., New York and London.
13. Agashe, S.N. (1995) - Palaeobotany, Oxford & IBH, New Delhi.
14. Siddiqui, K.A. (2002) - Elements of Palaeobotany, Kitab Mahal, Allahabad.
15. Thomas, B.A. & Spicer R.A. (1987) - The Evolution and Palaeobiology of land plants. Discordies Press, Fortland, USA.
16. Spicer, R.A. & Thomas, B.A. (1986) - Systematic and taxonomic approaches in Palaeobotany. Systematic Association Special Volume.
17. Singh Savindra (1998) - Geomorphology, Prayag Publication, Allahabad.
18. Chorley, R.G. (1972) - Spatial Analysis in Geomorphology, Methuen, Londonpta
19. Dr. V.S. Kale & Abhijit Gupta - Introduction to Geomorphology.
20. Garner H.F. (1974) - The origin of the Landscape- A syntheses of Geomorphology, Oxford University Press London.

M. Sc. Botany Syllabus

Semester I –Minor -1 Research Methodology

Course code-

Credit - 04

PAPER I Research Methodology

Unit I

Foundation of Research: Meaning, Objectives, Motivation, Utility, Characteristics and Types. Characteristics of scientific methods – understanding the language of research-Concept, Construct, definition, Variable. Scientific Research Process. Steps of research, methods of research, research ethics. **Problem Identification & Formulation:** definition and formulating the research problem, Necessity of defining the problem, Importance of literature review in defining a problem. **Literature survey:** primary and secondary; web sources; critical literature review. Research Question - Investigation Question – Hypothesis testing - Qualities of a good hypothesis - Null hypothesis & Alternative Hypothesis.

Unit II

Research Design: Concept and Importance in Research - Features of a good research design - Exploratory Research Design - Concept, Types and uses, Descriptive Research Design - concept, types and uses. Experimental Design -Concept of Independent & Dependent variables. Biased and unbiased Research design.

Qualitative and Quantitative Research: Qualitative - Quantitative Research -Concept of measurement, causality, generalization, replication. Merging the two approaches. Biological data: Types of data - Qualitative data, Quantitative data ;

Unit III

Data Collection and analysis :Concept of Statistical population,Sample, Sampling Frame, Sampling Error, Sample size, Non Response.Characteristics of a good sample, sample distribution, Probability and Probability distributions. Determining size of the sample - Practical considerations insampling and sample size. Data analysis - Univariate analysis (frequency tables,bar charts, pie charts, percentages), Bivariate analysis - Cross tabulations andcChi-square test including testing hypothesis of association including Chi test,correlation and regression analysis, t-test, z-test, ANOVA- one way and two way.Interpretation of Data and Paper Writing: Graphical interpretation of data, Layout of a Research Paper, Journals, Ethical issues related to publishing, Plagiarism and Self- Plagiarism.

Unit IV

Measurement: Concept of measurement: what is measured? Problem in measurement in research - Validity and Reliability. Levels of measurement – Nominal , Ordinal, Interval, Ratio.
Sampling;IPR : Types, Copyrights in Scientific work, Patents in scientific research, Writing, a patent specification, patent filing and grant, infringement. Gene patenting, Farmer's rights, Plant Breeder's rights, Traditional knowledge and protection.

Reference books:

- 1) Garg, B. L.Karadia R. Agrawal, F. and Agrawal U. K., 2002. An Introduction to Research Methodology, RBSAPublishers
- 2) Kothari C. R.,1990. Research Methodology: Methods and Techniques New Age International418p.
- 3) Sinha S. C. and Dhiman A. K., 2002. Research Methodology Ess Publications 2 Columes.
- 4) Trochim W. M. K., 2005. Research Methods: The Concise Knowledge Base Atomic Dog Publishing.270P
- 5) Wadehra B. L., 2000. Law Relating to Patents, Trade Marks, Copyright Design and

Geographical Indications, Universal Law Publishing

6) Research Methodology: An Introduction-Stuart Melville and Wayne

7) Practical Research Methodology-Catherine Dawson

8) Research Methods for Science Michael P Marder

9) Research Methodology: Principle, Methods and Practices-Joshua O. Miluwi and Hina Rashid

10) Research Methodology: A Step By Step Guide for beginners- Ranjeet Kumar

11) How to Write and publish a Research Paper- Seventh Edition-Robert Day And Barbara Gastle

12) Introduction to Biostatistics and Research Methods- P S S Sunder Rao

13) Research Methodology and Scientific Writings- C George Thomas

M. Sc. Botany Syllabus
Semester II -Major (DSC)
Paper –V: Plant Physiology

Course code- PSCBOTT05

Credit - 04

UNIT – I:

Definition and 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, photosynthesis Physiological and ecological consideration (photosynthetic responses to light by the intact leaf, photosynthetic responses to carbon dioxide and temperature) coupled reaction and ATP Synthesis, the chemiosmotic-coupling hypothesis, ATP Synthesis in chloroplast and in mitochondria.

UNIT –II:

Respiration:- introduction, the respiratory substrate, fermentation, anaerobic and aerobic respiration, mechanism of respiration, Glycolysis, Citric acid cycle, oxidative pentose phosphate pathway, Plant mitochondrial electron transport, alternative pathway of electron transport chain, cyanide resistant chain, metabolic pool, respiratory ratio, measurement of R.Q., Regulation of respiration, respiratory enzymes, the non-oxidative enzymes, the oxidative enzymes, factor affecting the rate of respiration.

UNIT – III:

Solute transport and photo-assimilate translocation:- Mechanism of water transport through xylem; Pathway of translocation patterns of Translocation through phloem; Source and sink, Materials Translocated in the Phloem i.e. Sucrose, Amino acids, Hormones and some inorganic ions, Rate of Movement, Phloem loading: from chloroplast to sieve elements, Phloem Unloading: sink-to-source Transition, mechanism of translocation in the phloem.

UNIT – IV:

Sensory photobiology: Structure, function and mechanisms of action of phytochromes, cryptochromes and phototropins; stomatal movement; photoperiodism and biological clocks.

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

Stress physiology: Responses of plants to biotic (pathogen and insects) and abiotic (water, temperature and salt) stresses.

Laboratory Exercises:-

1. To prove Beer-Lambert's law using a suitable solution.
2. Extraction of chloroplast pigments from leaves and preparation of the absorption spectrum of chlorophyll and carotenoids.
3. To determine the chlorophyll a/ chlorophyll b ratio in C₃ and C₄ plants.
4. Isolation of intact chloroplasts and estimation of chloroplast proteins by spot protein assay.
5. Preparation of Leaf Protein Concentrates from green vegetables.

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. 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, Massachusetts, 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-238884.
15. Ranjan, purohit, Prasad 2003: Plant Hormones Action and Application, Agrobios(India), agro house, behind Nasranicinema Chopasani Road, Jodhpur.

Suggested Readings (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.21
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 Netherland.
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. **Ninfa, 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 Manikum: Biochemical Methods , New Age International (p) Limited Publishers 4835/24, Ansari Road, Daryaganj, New Delhi- 110002.

M. Sc. Botany Syllabus
Semester II -Major (DSC)
Paper –VI: Plant Development and Embryology

Course code- PSCBOTT06

Credit - 04

UNIT - I

Plant growth

Kinetics and pattern of growth

Shoot Development – Organization of shoot apical meristem (SAM); cytological and molecular analysis of SAM; control of cell division and cell communication; control of tissue differentiation.

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

UNIT - II

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

UNIT - III

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., egg, synergid-ultrastucture;role of central cell, antipodalcell; hantoria; cytoskeleton of the embryo sac; enzymatic isolation of embryo sac;types of embryo sac; nutrition of embryo sac.

UNIT - IV

Pollination – Pollination mechanism-biotic and abiotic pollination; floral attractions and rewards

Pollen – pistil interaction:stigma types and structure;stigmatic exudates, style- transmitting tissues,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 is a pollen- tube(chemotropism); pollen allelopathy

Laboratory Exercises/ 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*. Examination of shoot apices in a monocotyledon in both T.S. and L.S. to show the origin and arrangement of leaf primordia.
6. Study of alternate and distichous, alternate and superposed, opposite and superposed; opposite and decussate leaf arrangement.
7. Examination of rosette plants (*Launaea*, *Mollugo*, *Raphanus*, *Hyoscyamus* etc) and induction of bolting under natural conditions as well as by GA treatment.
8. 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.
9. 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.
10. 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.). Origin of lateral roots. Study of leguminous roots with different types of nodules.
11. Study of microsporogenesis and gametogenesis in sections of anthers.
12. 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. Study of cleistogamous flowers and their adaptations.
20. Study of nuclear and cellular endosperm through dissections and staining.
21. Isolation of zygotic globular, heart-shaped, torpedo stage and mature embryos from suitable seeds and polyembryony in citrus, jamun (*Syzygium cumini*) etc. by dissections.
22. Study of seed dormancy and methods to break dormancy.

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) Shivanna, K.R. and Rangaswamy, N.S. 1992. Pollen Biology: A Laboratory Manual. Springer-Verlag, Berlin.
- 18) Shivanna, 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

M. Sc. Botany Syllabus
Semester II -Major (DSC)
Paper –VII: Angiosperms -I

Course code- PSCBOTT08

Credit - 04

UNIT - I

Angiosperm Morphology (Vegetative and reproductive), Phyllotaxy, structural units and floral symmetry, dicot and monocot flower. Fruits and its types, Seeds types & structure: Dicot and monocot.

Structure, diversity origin and evolution of stamen, carpels; placentation types and evolution.

Inflorescence—its different types and importance, Floral adaptation to different pollinators.

UNIT - II

Angiosperm Taxonomy: Scope, aims, principles of taxonomy, historical development of plant taxonomy, relative merits and demerits of major systems of classifications (Artificial, Natural and Phylogenetic systems).

Taxonomic structure: taxonomic hierarchy, concept of taxa, concept of species, concept of genus and family.

Taxonomic character: Heterobathmy, Analytic Vs. Synthetic Character, Qualitative Vs Quantitative Characters.

UNIT - 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.

UNIT - 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

Laboratory Exercises:-

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 different types of Inflorescence.

4. To study the phyllotaxy in locally available different angiosperm plants.
5. To study the variation in stamens and carpels.
6. To study placentation types in various taxa.
7. To study the modifications of leaf.
8. To study the modifications of Stem.
9. To study the modifications of root.
10. To study the Dicot and monocot seed.
11. To study the different types of fruits.
12. To study the floral adaptations for different pollination (Wind pollination, Water pollination and Insect pollination).
13. To study anatomical features of various taxa.
14. To study embryological features of various taxa.
15. To study palynological features of various taxa.
16. To study cytological features of various taxa.
17. To prepare a cladogram on the basis of various morphological features of the species belonging to a genus.

Suggested Readings:

1. Devis, P.H. and Heywood, V. H. 1973. Principles of angiosperms taxonomy. Robert E. Kreiger Pub. Co. Newyork.
2. Grant, V. 1971. Plant Speciation, Columbia University press, London. Grant W. F. 1984. Plant Biosystematics. Academic press, London.
3. Harisson, H.J. 1971. New concept in flowering plant Taxonomy. Hickman educational books Ltd. London.3
4. Hislop-Harisson, J. 1967. Plant Taxonomy. English Language Book Sco. And Edward Arnold Pub. Ltd, UK.
5. Heywood, V. H. and Moore, D. M. 1984. Current concepts in Plant Taxonomy. Academic Press, London.
6. Joncs, A. D. and Wibins, A. D. 1971. Variation and adaptation in Plant species Hickman and Co. New York.
7. Jones, S. B., Jr.andLuchsinger, A. E. 1986. Plant Systematics (gd edition). McGraw-Hill Book Co., New York. Nordentam,
8. B., El Gazaly, G. and kassas, M. 2000. Plant systematic for 2ft century. Portlant press. Ltd, London.
9. Radford, A. E. 1986. Fundamentals of plant systematic. Harper and Raw publication, USA.

10. Solbrig, O.T. 1970. Principles and methods of plant Sytematics. The Macmillan Co. Publication Co. Inc., USA.
11. Woodland, D. W. 1991. Contemporary Plant Syatematics, Pentice Hall, New Jersery.
12. Takhtajan, A. L. 1997. Diversity and classification of Flowering Plants. Columbia University Press, New York.
13. Stebbins, G. L. 1974. Flowering Plants-evolution Above species Level. Edvard Arnold Ltd, London. Jones, A. D. and Wibins, A. D. 1971. Variation and adaptation in Plant species Hickman and Co.
14. Jones, S. B., Jr.andLuchsinger, A. E. 1986. Plant Systematics (gd edition). McGraw Hill Book Co., Newer RH 1975 Communities and Ecosystems (2nd ed) MacMillan, New York.
15. Davis, P.H. and V.H. Heywood. 1973. Principles of Angiosperm Taxonomy. Kreiger, New York.
16. Jeffrey, C. 1982. An Introduction to Plant Taxonomy. University Press, Cambridge.
17. Judd, W.S., C.S. Campbell, E.A. Kellogg and P.F. Stevens. 1999. Plant Systematics: A Phylogenetic Approach. Sinaeur Associate, Inc., Sunderland, MA, USA.
18. Lawrence, G.H.M. 1951. Taxonomy of Vascular Plants. Macmillan, New York.4
19. Naik, V.N. 1984. Taxonomy of Angiosperms. Tata McGraw-Hill, New Delhi.
20. Sivarajan, V. V. 1984. Principles of Plant Taxonomy, Oxford and IBH publishing Co. New Delhi, (1985).
21. Stace, C.A. 1989. Plant Taxonomy and Biosystematics. Edward Arnold, London.
22. Stuessy, T.F. 1990. Plant Taxonomy. Columbia Univ. Press, New York.
23. Stuessy, T. F., 1990. Plant Taxonomy. Bishen Singh Mahendra Pal Singh, Dehra Dun.
24. Singh, Gurcharan, 2004. Plant Systematics - Theory and Practice, Oxford and IBH Publishing Co. New Delhi(2nd Ed.).
25. Gurcharan Singh.2010.Plant Systematic –An integrated Approach.(3rd).Published by Science Publishers, Enfield, NH, USA An imprint of Edenbridge Ltd., British Channel Islands.

M. Sc. Botany Syllabus

Semester II – Paper- VIII (Major Elective DSE)

Molecular Biology and Plant Biotechnology - II

UNIT I:

Ribosomes: Structure and functions.

Transcription & Translation: Transcription in prokaryotic and eukaryotic cells, plant promoters, transcription factors, types of RNA and their function, splicing, mRNA transport, rRNA biosynthesis; translation in prokaryotic and eukaryotic cells, structural levels of proteins, post-translational modification; structure and role of tRNA.

UNIT II:

Gene structure and expression: Fine structure of gene, Cis-trans test; fine structure analysis in eukaryotes; introns and their significance, RNA splicing; regulation of gene expression in pro- and eukaryotes.

Protein sorting: Machinery involved, vesicles, coat proteins; protein targeting to plastids, mitochondria, peroxisomes, nucleus, vacuoles; modification during transport.

UNIT 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; genetics 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; site-specific recombination; chromosome mapping, linkage group, genetic markers, construction of molecular maps, correlation of genetic and physical maps; Somatic cell genetics - an alternative approach to gene mapping.

UNIT IV:

Cell cycle and apoptosis: Control mechanisms, role of cyclins and cyclin dependent kinases; retinoblastoma and E2F proteins; cytokinesis and cell plate formation; programmed cell death in plants; regulation in plant growth and development.

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.

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. Restriction digestion of plant DNA, its separation by agarose gel electrophoresis, visualization by ethidium bromide staining.
4. To study in vitro transcription.
5. To study in vitro translation.

6. To study conjugation in bacterial cells.
7. Isolation of RNA and quantification by spectrophotometric method.

Suggested readings:

1. Alberts, B., Bray, D., Lewis, J., Raff, M., Roberts, K. and Watson, J.D. 1999. Molecular Biology of Cell, Garland Publishing, Inc., New York.
2. Buchanan, B. B., Gruissem, W. and Jones, R. L. 2000 Biochemistry and Molecular Biology of Plants. American Soc. Of Plant Physiologists, Maryland, USA.
3. De Robertis, E.D. P. and De Robertis, E.M.F. Cell and Molecular Biology 8th Ed. B. I. Waverly Pvt. Ltd., New Delhi.
4. Karp, G. 1999 Cells and Molecular Biology; Concepts and Experiments. John Wiley & Sons, Inc., USA.
5. Khush, G.s. 1973 Cytogenetics of Aneuploids, Academic Press, New York, London
6. Kleinsmith, L.J. and Kish, V.M. 1995 Principles of Cell and Molecular Biology (2nd Edi.) Harper Collins Coll. Publisher, New York, USA. Lewin, B. 2000 Gene VII Oxford Univ. press, New York.
7. 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.
8. Malacinski, G. M. and Freifelder, D. 1998 Essentials of Molecular Biology (3rd Edi.) Jones and Bartiet Pub. Inc., London.
9. Russel, P. J. 1998 Genetics (5th Edi.) The Benjamin/ Cummings Publishing Com. Inc., USA
10. Sunstad, D. P. and Simmons, M. J. 2000 Principles of Genetics (2nd Edi.) John Wiley & Sons Inc., USA.
11. 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

M. Sc. Botany Syllabus

Semester II – Paper-VIII (Major Elective DSE)

Reproductive Biology of Angiosperms - II

Unit 1:

Pollen: Structure of pollen grain (microspore) Pollen wall structure, MGU (male germ unit) structure, NPC system, pollen wall proteins, adaptive significance of pollen wall.

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

Unit 2:

Microgametogenesis and Male gametophyte development: Development of the male gametophyte (a. Development before pollination. b. Dehiscence of anther and dispersal of developing pollens. (c) after Pollination) formation of vegetative and generative cells, differential behavior of sperms, gene expression during pollen development.

Pollination: Pollination types and significance; adaptations, Pollination-pollination mechanism, biotic and abiotic pollination, floral attractants and rewards.

Unit 3:

Ovule: Its types and its structural details

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

Unit 4:

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

Self incompatibility - Basic concepts, mechanism of self compatibility (interspecific, intraspecific, homomorphic, heteromorphic, GSI, SSI, CSI and LSI); Recognition and rejection reaction, importance of self compatibility, Methods to overcome self-incompatibility: mixed pollination, bud pollination, stub pollination; Modification of stigma surface, parasexual hybridization (in brief with examples), importance of self compatibility.

Practicals :

Major exercises:

1. 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.(Locally available plants)
2. Cytology of pollen inhibition in self and inter specific incompatibility, application of some techniques to overcome incompatibility.
3. Techniques, Familiarity with phase contrast, polarizing, fluorescence and electron microscopy, whole mounts, dissection and macerations, permanent double stained microtome sections, photo microscopy.
4. Interpretation of electron micrographs (SEM, TEM) of pollen. (slides/photographs/fresh material).
5. Preparation of permanent slides using micro-technique: Embedding and block making.
6. Preparation of permanent slides using micro-technique: Section cutting and processing for staining.
7. Study of pollen morphology (polarity, symmetry, shape, size, aperture) using acetolysis method (slides/photographs/fresh material).
8. To study different types of pollination and adaptations. (slides/photographs/fresh material).
9. Calculation of percentage germination in different media using hanging drop and or sitting drop method

Minor exercises:

10. Study from the permanent preparations.

- a. Structure and types of ovule.
 - b. Megasporogenesis,
 - d. Embryo sac and its types.
 - c. Development of endosperm.
 - d. Different types of Endosperms
 - d. Sketching of ovular structure, embryo sac, embryo with the help of camera lucida.
11. Experiments on intra- ovarian pollination.
 12. To study hybridization in Pea plant (Emasculation, Bagging and Tagging).
 13. To study the Piston mechanism and Lever mechanism of pollination.
 14. To study the nectar glands in locally available plants.
 15. To study floral adaptation for different types of pollination based on pollinating agents.
(eg. *Vallisneria*, *Calotropis*, *Salvia*, *Kigelia*, *Agave*, *Lantana*, *Butea*, *Bombax* etc. And Other locally available plants)
 15. Male germ unit (MGU) through photographs and schematic representation.
 16. To study psuedomonads, polyads, pollinia(slides/photographs,fresh material).

Suggested Readings:

1. Cartson P.S. (1973) The use of protoplasts of genetic research. Proc. Nat. Acad. Sci. USA, 70, 598-602.
2. Asker S. 1979, Progress in apomixis research. Hereditas 91, 231-240.
3. Barnier, G. 1986, The flowering process as an example of plastic development. Soc. Expt.. Biol. 40: 257-286.
4. Barth, F.G. 1991, insects and flowers, Princeton Univ. Press. Princeton.
5. Battaglia, E. 1963. Apomixis In recent advances in the embryology of angiosperms (ed P. Maheshwari), pp- 264, Intt. Soc. Plant Morphologists, Univ. Delhi.
6. Bhandari N. N. 1984, The microsporangium in embryology of angiosperms (ed B.M. Johri) Springer- Verlag, Berlin, pp. 53-121.
7. Bhandari N.N., M. Bhargava and P. Chitralkha 1986, Cellularization of free nuclear endosperm of *Pappaver somniferum* L. Phytomorphology, 36, 357-366.
8. Bhojwani S.S. and M.K. Rajdan 1983, Plant tissue culture, Theory and Practice Elsevier, Amsterdam.

9. Bhojwani S.S./Bhatnagar S.P. & Dantu P.K. 2015. The Embryology of Angiosperms, 6th Edition Front Cover Vikas Publishing House.
10. Bhojwani, S.S. and Bhatnagar, S.P. 2000. The Embryology of Angiosperms. Vikas Publishing House, Delhi.
11. Boesewinkel F.D. and Boman F. 1984, The seed structure in embryology of angiosperms (ed B.M.Johri), Springer- Verlag, Berlin, pp. 567-610.
12. Bouman F. 1984 The ovule in embryology of angiosperms (ed B.M.Johri), Springer-Verlag, Berlin, pp. 123-157.
13. Cartson P.S., Smith N.H., Dearing R.D. (1972) Parasexual interspecific plant hybridization. Proc. Nat. Acad. Sci. USA, 69, 2292-2294.
14. Chitralekha P. and N.N. Bhandari 1991, Post fertilization development of antipodal cells in Ranunculus scferatus. Phytomorphology 41, 200-212.
15. Ciampolini F.M., Nepi and E. Pacini 1993, tapetum development in Cucurbita pepo (Cucurbitaceae) Pt. Syst. Evol. (Suppl) 7-13-22.
16. Cocking E.C. 1960, A method for the isolation of plant protoplasts and vacuoles. Nature (London) 187-927-929.
17. Cocking E.C. 1970, Virus uptake, cell wall regeneration and virus multiplication in isolated plant protoplasts. Int. Rev. Cytol 28-89-124
18. Johri, B. M., Srivastava, P. S., & Singh, N. (2001). Reproductive Biology of Angiosperms. Reproductive Biology of Plants, 237–272. doi:10.1007/978-3-642-50133-3_11
19. Johri, B.M. (1984). Embryology of Angiosperms ; Editors · Brij Mohan Johri ; DOI · ; Publisher · Springer Berlin, Heidelberg. <https://doi.org/10.1007/978-3-642-69302-1>
20. Knox, R.B. (1984). The Pollen Grain. In: Johri, B.M. (eds) Embryology of Angiosperms. Springer, Berlin, Heidelberg. https://doi.org/10.1007/978-3-642-69302-1_5
21. Maheshwari, P. , 1950. An Introduction to Embryology of Angiosperms. Tata McGrew Hill Publishing Co. , New Delhi.
22. Mauro Cresti, Stephen Blackmore, Jacobus L. van Went (2012). Atlas of Sexual Reproduction in Flowering Plants. Springer Verlag Berlin.
23. Mishra SR (2009) Understanding Plant Reproduction. Discovery Publishing House New Delhi.
24. Rajeshwari Sharma & A.K. Sharma (2009). Structure Development and Reproduction in Flowering Plants. Jagdhamba Publishing Co. New Delhi.
25. Shi J. (2018). Plant Development & Reproduction. Magnum Publishing House New Delhi. Ueli Grossniklaus Edt. (2019). Plant Development and Evolution. Academic Press. <https://courseware.cutm.ac.in/courses/reproductive-biology-of-angiosperms/>

M. Sc. Botany Syllabus

Semester II –Paper-VIII (Major Elective DSE)

Paleobotany – II

UNIT– I:

Gymnosperm and early evolution (*Archeosperma*, *Elkinsia* and *Morentia*) of seed habit stages. Study of Pteridosprmales – Lyginopteridaceae (*Heterangium*); Cycadeoidales – Wielandiellaceae (*Wielandiella*). Fossil Cycads (*Nilssonia*, *Baenia*, *Androstrobus*).

UNIT– II:

Fossil Gymnosperm – Cordaitales- Cordaitaceae (*Dadoxylon*); Coniferales- Lebachiaceae (*Lebachia*), Voltziaceae (*Voltziopsis*), Palissyaceae (*Palissya*) and phylogenetic consideration of all the orders.

UNIT- III:

Formation of the Deccan traps and Intertraps. Age and floristic composition of the Deccan Intertraps in relation to Pteridophytes, Gymnosperms and Angiosperms. Paleoclimate and Paleogeography of the Deccan Intertraps. Fossiliferous localities & paleobiodiversity of Chandrapur & Gadchiroli district.

UNIT- IV:

Paleopalynology-Important features of spores and pollen morphology. Role spores and pollen in stratigraphy. Palaeopalynological studies, microfossils and its application. Indian Gonwana-Its stratigraphy and classification (Two fold and three fold). Index fossil, Living fossil.

Suggested Laboratory and Field Exercises

Major Exercises:

1. Study of the Deccan Intertrappean flora of India. Pteridophytes, Gymnosperms and Angiosperms- flowers and fruits.
2. Fossil Gymnosperm- *Heterangium*, *Wielandiella*, *Nilssonia*, *Baenia*, *Androstrobus*, *Dadoxylon*, *Lebachia*, *Voltziopsis*, *Palissya*.
3. Important features of spores and pollen morphology and technique to study them (Maceration)
4. Acetolysis method for studies of morphology of modern spores (Pteridophytes) and pollen grains (Gymnosperms and Angiosperms).
5. Study of fossiliferous localities & paleobiodiversity of Chandrapur & Gadchiroli district.

Minor Exercises:

6. Gymnosperm and early evolution of seed habit stages (*Archeosperma*, *Elkinsia* and *Morentia*)
7. Indian Gonwana-Its stratigraphy and classification (Two fold and three fold).
9. Short Notes on Index fossil and Living fossil.
10. Exploration and excursion to different fossiliferous localities.
11. Preparation of practical record/submission of collection and tour report of excursion.

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, origin and evolution of Gymnosperms, Columbia Uni. Press-New York.
5. Beck, C.B. (1976) - Current status of the Progymnospermosida, 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.
19. Stewart, W.N. and Rothwell G.W. (1993)- Palaeobotany and the Evolution of Plants, Cambridge University Press.
20. Arnold, C.A. (1947) - Introduction to Palaeobotany, Mc-Graw Hill Book Co. Inc., New York and London.

21. Agashe, S.N. (1995) - Palaeobotany, Oxford & IBH, New Delhi.
22. Siddiqui, K.A. (2002) - Elements of Palaeobotany, Kitab Mahal, Allahabad.
23. Thomas, B.A. & Spicer R.A. (1987) -The Evolution and Palaeobiology of land plants. Discordies Press, Fortland, USA.
24. Spicer, R.A. & Thomas, B.A. (1986) - Systematic and taxonomic approaches in Palaeobotany. Systematic Association Special Volume.

M. Sc. Botany Syllabus
Semester II –Minor-2
On Job Training (OJT/FP)
Course code- Credit - 04