

University of Rajasthan Jaipur

SYLLABUS

M.Sc. BOTANY

(Annual Scheme)

M.A./M.Sc. (Previous) Examination 2021

M.A./M.Sc. (Final) Examination 2022

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M.Sc. (BOTANY)
M. Sc. (ANNUAL PATTERN)

M. Sc. Previous

Paper I	Cell & Molecular Biology of Plants
Paper II	Cytology, Genetics & Cytogenetics
Paper III	Biology & Diversity of Lower Plants: Cryptogams
Paper IV	Taxonomy & Diversity of Seed Plants
Paper V	Plant Physiology & Metabolism
Paper VI	Microbiology and Plant Pathology

M.Sc. Final

Paper VII	Plant Morphology, Developmental Anatomy and Reproductive Biology
Paper VIII	Plant Ecology
Paper IX	Plant Resource Utilization & Conservation
Paper X	Biotechnology & Genetic Engineering of Plants & Microbes
Paper XI	Elective I
Paper XII	Elective II

Elective Papers XI & XII

Papers XI (a) : Advanced Plant Pathology I

Paper XII (a) : Advance Plant Pathology II

OR

Papers XI (b) : Seed Science and technology I

Paper XII (b) : Seed Science and technology II

OR

Papers XI (c) : Ecosystem Ecology

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Paper XI (c) : Advanced Plant Biology

OR

Papers XI (d) : Advanced Plant Physiology I

Paper XII (d) : Advanced Plant Physiology II

OR

Papers XI (e) : Advanced Morphology and Morphogenesis- I

Paper XII (e) : Advanced Morphology and Morphogenesis- II

OR

Papers XI (f) : Biosystematics of Angiosperms I

Paper XII (f) : Biosystematics of Angiosperms II

OR

Papers XI (g) : Biotechnology- I

Paper XII (g) : Biotechnology- II

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M.Sc. (Previous)

There will be six papers in theory, each of three hours duration, 100 marks each and two practicals carrying 150 marks each (10% marks are reserved for viva and 15% records in each examination). Each practical examination will be of 6 hours duration to be completed in one day.

Each theory paper will have 9 questions, out of which a student has to attempt 5 questions and the question No. 1 will be compulsory. The question No. 1 will carry 20 marks and will be of short type of questions with a limit of 20 words.

M.Sc. (Final)

There will be six papers, four compulsory and two elective in theory of 3 hours duration carrying 100 marks each and two practicals each as follows:

- i. Practical for compulsory papers of 200 marks of 8 hours duration to be completed in two days.
- ii. Practical for elective papers 100 marks of 4 hours duration to be completed in one day.

Each theory paper will have 9 questions, out of which a student has to attempt 5 questions and the question No. 1 will be compulsory. The question No. 1 will carry 20 marks and will be of short type of questions with a limit of 20 words.

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M.Sc. Botany
Scheme of Examination

M.Sc. (First)

There will be two papers, each of three hours duration. Each paper will carry 100 marks. The total marks for the examination will be 200. Each practical examination will be of 3 hours duration to be completed in one day.

Each theory paper will have 9 questions, out of which a student has to attempt 5 questions including question No. 1 which is compulsory. The question No. 1 will carry 20 marks and will be of objective type. The other 8 questions will be of subjective type. Each question will carry 10 marks.

M.Sc. (Final)

There will be six papers, four from theory and two from practical. Each theory paper will be of three hours duration carrying 100 marks each. The total marks for the examination will be 600.

The scheme of examination is as follows:

- (i) Practical for one paper of 200 marks and 3 hours duration to be completed in one day.
- (ii) Practical for one paper of 100 marks and 3 hours duration to be completed in one day.
- (iii) Theory paper will have 9 questions, out of which a student has to attempt 5 questions including question No. 1 which is compulsory. The question No. 1 will carry 20 marks and will be of objective type. The other 8 questions will be of subjective type. Each question will carry 10 marks.

- Paper-I : Cell and Molecular Biology of Plants
- Paper-II : Cytology and Cytogenetics
- Paper-III : Biology and Diversity of Lower Plants : Cryptogams
- Paper-IV : Diversity and Diversity of Seed Plants
- Paper-V : Plant Physiology and Metabolism
- Paper-VI : Microbiology and Plant Pathology

Scheme of Examination **Max. Marks : 100**
The paper will have 9 questions, out of which a student has to attempt 5 questions including the question No. 1 which will be compulsory.

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patory. The question No. 1 will carry 20 marks and will be of several short objective type questions such as multiple choice type, one line answer type, one word type and fill in the blank type.

Unit - I

The dynamic cell: Structural organization of the plant cell, specialized plant cells, chemical composition, Biochemical energetics.

Cell wall: Structure and function of cellulose, hemicellulose, pectin, lignin.
A. Plasma membrane: Structure, composition, functions, sites for ATP synthesis, transport of small molecules and macromolecules, osmotic potential, water potential.

Chloroplast: Structure, function, photosynthesis, electron transport, photosynthesis, microtubule organization, plant vacuoles, cytoskeleton, plant cell wall, plant cell division.

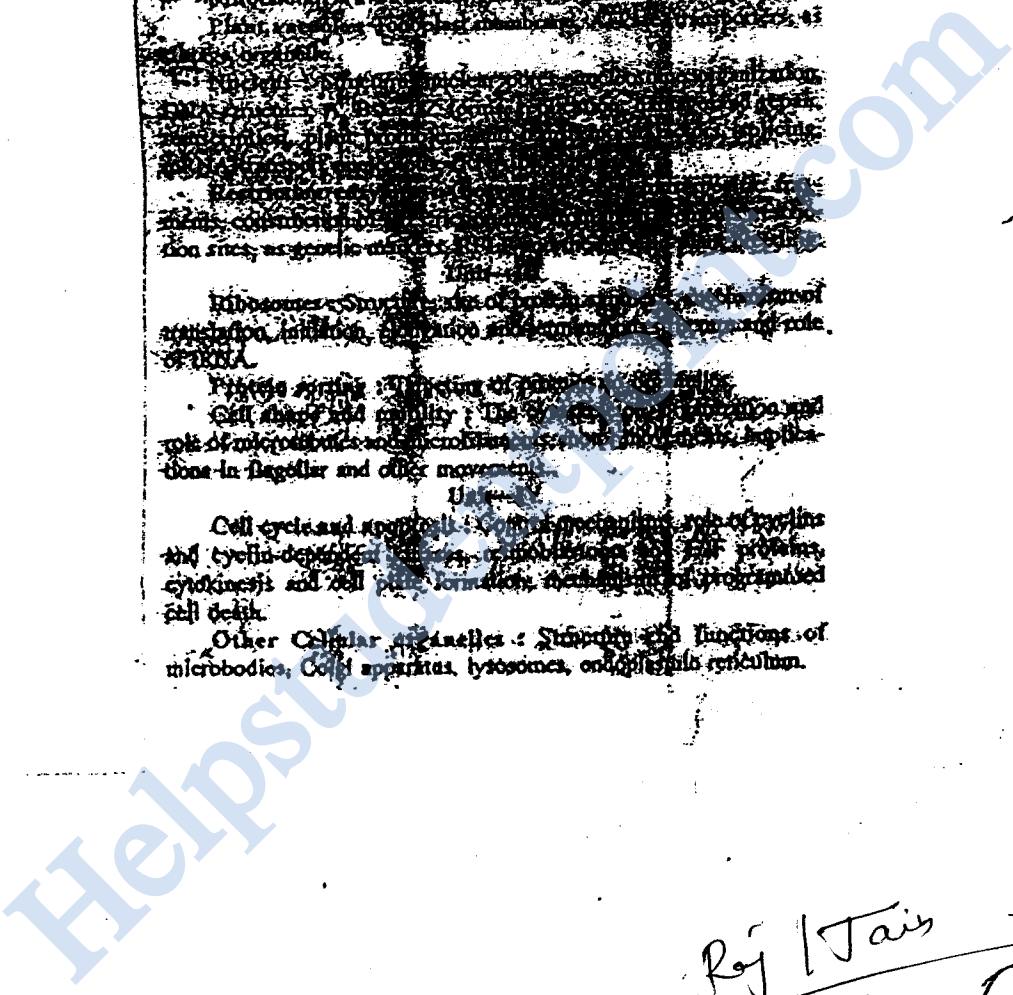
Plant vacuoles: Structure, function, osmotic potential, water potential, plant cell wall, plant cell division.

Ribosomes: Structure, function, protein synthesis, role of DNA, RNA, ribosomes, cytoskeleton, plant cell wall, plant cell division.

Plant cell wall: Structure, function, cellulose, hemicellulose, pectin, lignin, plant cell wall, plant cell division.

Cell cycle and apoptosis: Cell cycle, regulation of cell cycle, cell cycle-dependent kinases, cell cycle, plant cell wall, plant cell division.

Other Cellular organelles: Structure and functions of mitochondria, Golgi apparatus, lysosomes, and endoplasmic reticulum.



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Techniques in cell biology - Immunotechniques, in situ hybridization to locate transcripts in cell types, FISH, GISH, confocal microscopy.

Suggested Reading

1. Lewis, B. 200. Genes. WIL. Oxford University Press, New York.
2. Alberts, B., Bray, D., Lewis, J., Raff, M., Roberts, K. and Watson, J., 1999. Molecular Biology of the Cell. Garland Publishing, Inc. New York.
3. Wolfe, S.L. 1997. Molecular and Cellular Biology. Wadsworth Publishing USA.
4. Rood, T. 1997. Plant Biology. Wadsworth Publishing Co., California USA.
5. Krieger, R. 2000. Methods in Cell Wall Biochemistry, CRC Press, Boca Raton.
6. Buchanan, B.B. 1997. Biochemistry and Biophysics, 2nd Edition. W. H. Freeman & Co., New York.
7. De, D.M. 2000. Plant Cell Wall. Academic, Australia.
8. Kleinsmith, L.J. and Liou, J.M. 1975. Principles of Cell and Molecular Biology. 2nd Edition. Harper Collins College Publishers, New York.
9. Datta, H., Bera, S., Ghosh, S., Mandal, S., Ghosh, D. and Datta, J. 2000. Cell Biology (Bio-Physical). Wiley, New York.

See the following books:
Annual Review of Cell Biology and Molecular Biology.
Current Advances in Cell Biology.
Trends in Plant Biology.
Natura Reviews: Molecular and Cell Biology.

Suggested laboratory exercises

1. Isolation of ribosomes and the activity of the marker enzyme, succinate dehydrogenase (SDH).
2. Isolation of chloroplasts and SDS-PAGE profile of proteins to demonstrate the two subunit of Rubisco.
3. Isolation of nuclei and identification of histones by SDS-PAGE.
4. Isolation of plant DNA and its quantitation by a spectrophotometric method.
5. Isolation of DNA and preparation of 'cot' curve.

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6. Restriction digestion of plant DNA, its separation by agarose gel electrophoresis and visualization by ethidium bromide staining.

7. Isolation of RNA and quantification by a spectrophotometric method.

8. Separation of plant RNA by agarose gel electrophoresis and visualization by EtBr staining.

9. Northern blot analysis using a gene specific probe.

10. Southern blot analysis using a gene specific probe.

11. Various cell techniques - Laboratory methods: TUNSA and staining.

12. Staining of cells with FDA for cell viability and cell wall staining.

13. Staining of SP and TUNSA.

14. Chemicals and kits for conducting various laboratory experiments are available at the following addresses:

1. Bangalore Gene and Gene for Biotechnology (G&G) Laboratories (PVT) Ltd., Bangalore.

2. Biorad and Thomson, J. 1978. Methods in plant cell biology and biotechnology. IRL Press, Oxford.

3. Glover, D.M. and Hanks, R.D. (Eds), 1988. Plant Cell Culture: A Practical Approach. IRL Press, Oxford.

4. Oxford University Press, Oxford.

5. Jones, G.S. and Jones, G.S. (Eds), 1988. Plant Cell Culture: A Practical Approach. IRL Press, Oxford.

6. Jones, G.S. and Jones, G.S. (Eds), 1988. Plant Cell Culture: A Practical Approach. IRL Press, Oxford.

7. Jones, G.S. and Jones, G.S. (Eds), 1988. Plant Cell Culture: A Practical Approach. IRL Press, Oxford.

8. Jones, G.S. and Jones, G.S. (Eds), 1988. Plant Cell Culture: A Practical Approach. IRL Press, Oxford.

9. Jones, G.S. and Jones, G.S. (Eds), 1988. Plant Cell Culture: A Practical Approach. IRL Press, Oxford.

10. Jones, G.S. and Jones, G.S. (Eds), 1988. Plant Cell Culture: A Practical Approach. IRL Press, Oxford.

11. Jones, G.S. and Jones, G.S. (Eds), 1988. Plant Cell Culture: A Practical Approach. IRL Press, Oxford.

12. Jones, G.S. and Jones, G.S. (Eds), 1988. Plant Cell Culture: A Practical Approach. IRL Press, Oxford.

13. Jones, G.S. and Jones, G.S. (Eds), 1988. Plant Cell Culture: A Practical Approach. IRL Press, Oxford.

14. Jones, G.S. and Jones, G.S. (Eds), 1988. Plant Cell Culture: A Practical Approach. IRL Press, Oxford.

15. Jones, G.S. and Jones, G.S. (Eds), 1988. Plant Cell Culture: A Practical Approach. IRL Press, Oxford.

16. Jones, G.S. and Jones, G.S. (Eds), 1988. Plant Cell Culture: A Practical Approach. IRL Press, Oxford.

17. Jones, G.S. and Jones, G.S. (Eds), 1988. Plant Cell Culture: A Practical Approach. IRL Press, Oxford.

18. Jones, G.S. and Jones, G.S. (Eds), 1988. Plant Cell Culture: A Practical Approach. IRL Press, Oxford.

19. Jones, G.S. and Jones, G.S. (Eds), 1988. Plant Cell Culture: A Practical Approach. IRL Press, Oxford.

20. Jones, G.S. and Jones, G.S. (Eds), 1988. Plant Cell Culture: A Practical Approach. IRL Press, Oxford.

21. Jones, G.S. and Jones, G.S. (Eds), 1988. Plant Cell Culture: A Practical Approach. IRL Press, Oxford.

22. Jones, G.S. and Jones, G.S. (Eds), 1988. Plant Cell Culture: A Practical Approach. IRL Press, Oxford.

23. Jones, G.S. and Jones, G.S. (Eds), 1988. Plant Cell Culture: A Practical Approach. IRL Press, Oxford.

24. Jones, G.S. and Jones, G.S. (Eds), 1988. Plant Cell Culture: A Practical Approach. IRL Press, Oxford.

25. Jones, G.S. and Jones, G.S. (Eds), 1988. Plant Cell Culture: A Practical Approach. IRL Press, Oxford.

26. Jones, G.S. and Jones, G.S. (Eds), 1988. Plant Cell Culture: A Practical Approach. IRL Press, Oxford.

27. Jones, G.S. and Jones, G.S. (Eds), 1988. Plant Cell Culture: A Practical Approach. IRL Press, Oxford.

28. Jones, G.S. and Jones, G.S. (Eds), 1988. Plant Cell Culture: A Practical Approach. IRL Press, Oxford.

29. Jones, G.S. and Jones, G.S. (Eds), 1988. Plant Cell Culture: A Practical Approach. IRL Press, Oxford.

30. Jones, G.S. and Jones, G.S. (Eds), 1988. Plant Cell Culture: A Practical Approach. IRL Press, Oxford.

31. Jones, G.S. and Jones, G.S. (Eds), 1988. Plant Cell Culture: A Practical Approach. IRL Press, Oxford.

32. Jones, G.S. and Jones, G.S. (Eds), 1988. Plant Cell Culture: A Practical Approach. IRL Press, Oxford.

33. Jones, G.S. and Jones, G.S. (Eds), 1988. Plant Cell Culture: A Practical Approach. IRL Press, Oxford.

34. Jones, G.S. and Jones, G.S. (Eds), 1988. Plant Cell Culture: A Practical Approach. IRL Press, Oxford.

35. Jones, G.S. and Jones, G.S. (Eds), 1988. Plant Cell Culture: A Practical Approach. IRL Press, Oxford.

36. Jones, G.S. and Jones, G.S. (Eds), 1988. Plant Cell Culture: A Practical Approach. IRL Press, Oxford.

37. Jones, G.S. and Jones, G.S. (Eds), 1988. Plant Cell Culture: A Practical Approach. IRL Press, Oxford.

38. Jones, G.S. and Jones, G.S. (Eds), 1988. Plant Cell Culture: A Practical Approach. IRL Press, Oxford.

39. Jones, G.S. and Jones, G.S. (Eds), 1988. Plant Cell Culture: A Practical Approach. IRL Press, Oxford.

40. Jones, G.S. and Jones, G.S. (Eds), 1988. Plant Cell Culture: A Practical Approach. IRL Press, Oxford.

41. Jones, G.S. and Jones, G.S. (Eds), 1988. Plant Cell Culture: A Practical Approach. IRL Press, Oxford.

42. Jones, G.S. and Jones, G.S. (Eds), 1988. Plant Cell Culture: A Practical Approach. IRL Press, Oxford.

43. Jones, G.S. and Jones, G.S. (Eds), 1988. Plant Cell Culture: A Practical Approach. IRL Press, Oxford.

44. Jones, G.S. and Jones, G.S. (Eds), 1988. Plant Cell Culture: A Practical Approach. IRL Press, Oxford.

45. Jones, G.S. and Jones, G.S. (Eds), 1988. Plant Cell Culture: A Practical Approach. IRL Press, Oxford.

46. Jones, G.S. and Jones, G.S. (Eds), 1988. Plant Cell Culture: A Practical Approach. IRL Press, Oxford.

47. Jones, G.S. and Jones, G.S. (Eds), 1988. Plant Cell Culture: A Practical Approach. IRL Press, Oxford.

48. Jones, G.S. and Jones, G.S. (Eds), 1988. Plant Cell Culture: A Practical Approach. IRL Press, Oxford.

49. Jones, G.S. and Jones, G.S. (Eds), 1988. Plant Cell Culture: A Practical Approach. IRL Press, Oxford.

50. Jones, G.S. and Jones, G.S. (Eds), 1988. Plant Cell Culture: A Practical Approach. IRL Press, Oxford.

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Approach: III. Pre-Exam

Paper-II - Cell Biology and Genetics

Scheme of Examinations

Each paper will consist of 100 marks of which
attempt 5 questions including the question No. 1 which is com-
pulsory. The question No. 7 will carry 20 marks. The
remaining short questions will carry 10 marks each. The
time for the examination will be 3 hours and the
writing time will be 2 hours.

CELL BIOLOGY

Chromatin organization, Ultrastructure of
nucleolus and ribosomal RNA, heterochromatin, karyotype analysis, evolution, specialized chromosomes, B-chromosomes and sex chromosome pairing.

Structural and numerical changes, cell
division and translocation, mutation, gene
expression and control of gene expression,
production of recombinant DNA, allopolyploid
formation of higher eukaryotes, and
and monophyly.

GENETICS

Concepts of population genetics, Hardy-Weinberg
law, genetic drift, gene flow, natural selection,
in bacteria, genetics of mitochondria and chloroplasts,
male sterility.

Gene Structure and expression: Gene structure, de-
terminant, fine structure analysis of eukaryotes, and their
significance, RNA splicing, regulation of gene expression in
prokaryotes and eukaryotes. Pacopoly of genes, metabolic control,
attenuation and allelic exclusion.

Genetic recombination and gene expression. Recombination

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Suggested Readings

1. Alberts, Bruce, Lewis, J., Raff, M., Roberts, K. and Watson, J.D. 1999. Molecular Biology of the Cell (2nd edition). Garland Publishing, Inc. New York.
2. Athey, A.G., Dutton, J.R. and McDonald, J.R. 1999. The Science of Genetics. Saunders College Publishing, Fort Worth, USA.
3. Burnham, C.R. 1962. Dislocations in Cytogenetics. Burgess Publishing Co. Minnesota.
4. Busch, Hans and Robinson, L. 1982. Volume 2. The Cell Nucleus rDNA Part A. Academic Press.
5. Hartl, D.L. and Jones, E.W. 1997. Genetics: Principles and Analysis (4th edition). Jones & Bartlett Publishers, Massachusetts, USA.
6. Khush, G.S. 1973. Cytogenetics of Animals. Academic Press, New York, London.
7. Karp, G. 1999. Cell and Molecular Biology: Concepts and Experiments. John Wiley & Sons, Inc., USA.
8. Lewin, B. 2000. Gene VII. Garland University Press, New York, USA.
9. Lewis, R. 1997. Human Genetics: Concepts and Applications (2nd edition). WGB, McGraw-Hill, USA.
10. Malacinski, G.M. and Pfeiffer, D. 1987. Essentials of Molecular Biology (2nd edition). Jones and Bartlett Publishers, Inc., London.
11. Riesele, P.J. 1993. Genetics (2nd edition). The Benjamin/Cummings Publishing Company, USA.
12. Snustad, D.P. and Simmons, M.L. 1993. Principles of Genetics (2nd edition). John Wiley & Sons, Inc., USA.

Suggested Laboratory Experiments

1. Linear differentiation of chromosomes through banding techniques, such as Q-banding, G-banding and C-banding.
2. Silver banding for mapping nucleolar organizing region, where 18S and 28SrDNA are transcribed.
3. Orcein and Feulgen. Staining of dicentric and acrocentric chromosomes of *Chironomus* and *Drosophila*.
4. Characteristics and behavior of B chromosomes using maize or any other appropriate material.
5. Working out the effect of mono- and tri-activity on plant pheno-

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- 5. Type, fertility and mating behavior.
- 6. Induction of polyploidy using colchicine, different methods of the application of Colchicine.
- 7. Effect of induced and spontaneous polyploidy on plant phenotype, meiosis, pollen and seed fertility and fruit set.
- 8. Effect of aneuploid polyploidy on plant phenotype, chromosome pairing and chromosome segregation and pollen and seed fertility.
- 9. Meiosis of complex translocation heterozygotes.
- 10. Isolation of chlorophyll mutants, following irradiation and treatment with chemical mutagens.
- 11. Estimation of nuclear DNA content through microdensitometry and flow cytometry.
- 12. Fractionation and estimation of repetitive and unique DNA sequences in nuclear DNA.

References:

- 1. Furlan, L. and Nakayama, S. 1996: Plant Chromosomes: Laboratory Methods. CRC Press, Boca Raton, Fla.
- 2. Bawa, A.K. and Srinivasan, A. 1999: Plant Chromosomes: Manipulation and Biotechnology. Holtwood, Australia.
- 3. Raven III: Biology and Diversity of the Green Plants: Chloroplasts.

Students will have 2 questions out of which 1 is compulsory and 1 is optional including the question on which the student has to write the answer. No. of marks for each question will be 10.

Phycology: Algae in diversified habitats (terrestrial, freshwater, marine), thallic organization, cell ultrastructure, reproduction (vegetative, asexual, sexual) criteria for classification of algae: pigments, reserve food, flagella, classification system: features of Protochlorophyta, Chlorophyta, Charophyta, Xanthophyta, Bacillariophyta, Rhodophyta and Rhodophyta: with special reference to *Microcystis*, *Hydrocoleum*, *Drapetaldopsis*, *Coscinodiscus*, algal bloom, algal biofertilizers, algae as food, food and use in industry.

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Unit - II

Mycology : General characteristics of fungi, substrate relationship to fungi, cell ultrastructure, wall structure, cellular organization, cell wall composition, nutrition (saprophytic, biotrophic, symbiotic), heterothallism, heterokaryosis, secondary recombination in classification: Phylogeny of fungi, general account of Zygomycotina, Zygomycotina, Ascomycotina, Basidiomycotina, Deuteromycotina, with special reference to *Aspergillus*, *Claviceps*, *Mucor*, *Penicillium*, *Polyporus*, *Rhizopus*, *Phoma*, fungi in industry, medicine and as food, fungi on plants and humans, Mycorrhizae, fungal biocontrol agents

Unit - III

Bryophyta : Morphology, structure, reproduction and life history, distribution, classification, general account of *Funaria*, *Juncus*, *Manialex*, *Anthocerotales*, *Selagin*, *Polypodiaceae* and *Polypodiaceae*, with special reference to *Funaria*, *Notofly* and *Polypodium*, economic and social importance

Unit - IV

Pteridophyta : Morphology, structure, reproduction and life history, evolution of spore, general account of fossil plants, *Lycopodium*, *Gleichenia*, *Adiantum*, special reference to *Equisetum*, *Urtica*, *Funaria*, *Polypodium*

Alston, C.J. 1961. *Microbiology*. M. 1961. Microbiology. McGraw-Hill Book Co., New York.

Chatterjee, S.K. 1948. *Introduction to Fungi*. Ashish Press Ltd., New Delhi.

Mandhata, C.L. 1978. *Introduction to Plant Viruses*. Gird & Co. Ltd., Delhi.

Mehrotra, R.S. and Abeja, R.S. 1973. *An Introduction to Mycology*. New Age Intermediate Press.

Morris, I. 1976. *An Introduction to the Algae*. Cambridge University Press, U.K.

Parihar, N.S. 1991. *Bryophyta*. Central Book Depot, Allahabad.

Parihar, N.S. 1996. *Biology & Morphology of Pteridophytes*.

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TAXONOMY AND DIVERSITY OF SEED PLANTS

Gymnosperms

Unit I

Introduction: Gymnosperms, the vessel-less and fruitless seed plants varying in the structure of their sperms, pollen grains, pollen germination and the complexity of their female gametophyte; Evolution of Gymnosperms. Classification of Gymnosperms and their distribution in India. Brief account of the families of Pteridospermales (Lyginopteridaceae, Medullosaceae, Caytoniaceae and Glossopteridaceae). General account of Cycadeoidales and Cordaitales. Structure and reproduction in Cycadales, Ginkgoales, Coniferales, Ephedrales, Welwitschiales and Gnetales.

Unit II

TAXONOMY OF ANGIOSPERMS

- 1) Aims, components, and principles of Taxonomy; Alpha and Omega Taxonomy, documentation and scope.
- 2) Systems of Angiosperm classification: Cronquist, Dahlgren, Thorne and APG-II.
- 3) International Code of Botanical Nomenclature: Principles, rules and recommendations; Taxonomic concept: Hierarchy, species, genus, family and other categories.

Unit III

Numerical Taxonomy- Principles, concepts, operational taxonomic units (OTU), data processing and taxonomic studies, taximetric methods for study of population variation and similarity- coding, cluster analysis, cladistics, cladogram.

Taxonomic literature: Floras, Monographs, Icons, Library, Manuals, Index, Taxonomic keys.

Taxonomic tools and techniques: Herbarium, serological, Molecular technique, GIS and Mapping biodiversity.

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Unit IV

Taxonomic evidences: Morphology, Anatomy, Palynology, Embryology, Cytology, Phytochemistry and Genome analysis.

Phylogeny of Angiosperms: Ancestors of Angiosperms, time and place of origin of Angiosperms; habit of Angiosperm, primitive living Angiosperms, inter relationship among the major group of Angiosperms.

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Suggested Readings

- Bhatnagar, S.P. and Moitra, A. 1996. Gymnosperms. New Age International Pvt. Ltd., New Delhi.
- Cole, A.J. 1969. Numerical Taxonomy, Academic Press, London.
- Davis, 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, New York.
- Grant, W.F. 1984. Plant Biosystematics. Academic Press London.
- Harrison, H.J. 1971. New Concepts in Flowering Plant Taxonomy. Hieman Educational Book Ltd., London.
- Heslop-Harrison, J. 1967. Plant Taxonomy - English Language Book Soc. & Edward Arnold Pub. Ltd. U.K.
- Heywood, V.H. and Moore, D.M. 1984. Current Concepts in Plant Taxonomy. Academic Press, London.
- Jones, A.D. and Wilbins, A.D. 1971. Variations and Adaptations in Plant Species. Hiemand & Co. Educational Books Ltd., London.
- Jones, S.B. Jr. and Luchsinger, A.E. 1986. Plant Systematics (2nd edition). McGraw-Hill Book Co., New York.
- Nordenstam, B., El Gazaly, G. and Kassas, M. 2000 Plant Systematics for 21st Century. Portlant Press Ltd., London.
- Radford, A.E. 1986. Fundamentals of Plant Systematics. Harper & Row Publications, USA.
- Singh, H. 1978, Embryology of Gymnosperms. Encyclopaedia of Plant Anatomy X. Gebruder Bortraeger, Berlin.
- Solbrig, O.T. 1970. Principles and Methods of Plant Biosystematics. The MacMillan Co - Collier-MacMillan Ltd., London.
- Solbrig, O.T. and Solbrig, D.J. 1979. Population Biology and Evolution, Addison-Wesley Publishing Co. Ind., USA.
- Stebbins, G.L. 1974. Flowering Plant - Evolution Above Species Level. Edward Arnold Ltd., London.
- Stace, C.A. 1989. Plant Taxonomy and Biosystematics (2nd edition). Edward Arnold Ltd., London.
- Takhtajan, A.L. 1997. Diversity and Classification of Flowering Plants. Columbia University Press, New York.
- Woodland, D.W. 1991. Contemporary Plant Systematics, Prentice Hall, New Jersey.

Suggested Laboratory Exercises

Gymnosperms

1. Comparative study of the anatomy of vegetative and reproductive parts of cycas, Ginkgo, Cedrus, Abies, Picea, Cupressus, Araucaria, Cryptomeria, Taxodium, Podocarpus, Agathis, Taxus, Ephedra and Genetum.
2. Study of important fossil gymnosperms from prepared slides and specimens.

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Angiosperms

3. Description of a specimen from representative, locally available families

List of Locally Available Families :

(1) Ranunculaceae, (2) Capparidaceae, (3) Portulacaceae, (4) Caryophyllaceae, (5) Malvaceae, (6) Tiliaceae, (7) Sterculiaceae, (8) Zygophyllaceae, (9) Rhamnaceae, (10) Sapindaceae, (11) Leguminosae, (12) Combretaceae, (13) Myrtaceae, (14) Cucurbitaceae, (15) Umbelliferae, (16) Apiaceae, (17) Rubiaceae, (18) Asteraceae, (19) Primulaceae, (20) Plumbaginaceae, (21) Asclepiadaceae, (22) Convolvulaceae, (23) Solanaceae, (24) Boraginaceae, (25) Polemoniaceae, (26) Acanthaceae, (27) Pedaliaceae, (28) Martyniaceae, (29) Bignoniaceae, (30) Labiatae, (31) Nyctaginaceae, (32) Polygonaceae, (33) Chenopodiaceae, (34) Amaranthaceae, (35) Aizoaceae, (36) Molluginaceae, (37) Euphorbiaceae, (38) Commelinaceae and (39) Cyperaceae.

4. Description of a species based on various specimens to study intraspecific variation: a collective exercise.

5. Description of various species of a genus; location of key characters and preparation of keys at generic level.

6. Location of key characters and use of keys at family level.

7. Field trips within and around the campus; compilation of field notes and preparation of herbarium sheets of such plants, wild or cultivated, as are abundant.

8. Training in using floras and herbaria for identification of specimens described in the class.

9. Demonstration of the utility of secondary metabolites in the taxonomy of some appropriate genera.

10. Comparison of different species of a genus and different genera of a family to calculate similarity coefficients and preparation of dendrograms.

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Paper - V : Plant Physiology and Metabolism

Scheme of Examination
Each paper will have 9 questions, out of which 4 must be attempted. The question No. 1 will carry 20 marks and will be of short-answer type of questions. The remaining 8 questions will be of long-answer type and will be of 10 marks each. The questions will be of the type of questions which require multiple choice answers, short-answer type and fill in the blanks type.

Water relations of plants : Unifoliar, physical properties of water, osmotic potential, water potential, apparent free space, movement of water, Soil-Plant-Atmosphere Continuum (SPAC), regulation of transpiration, signal transduction in guard cells, membranes, transport, passive - non-mediated transport and active transport, Primary-mediated transport, ATP-driven active transport, symplasm, Apoplast ion channels.

Enzymes, Vitamins, Proteins and Enzymes : Nod factor, root nodule, haemoglobin, function, structure of amino acids, stereochemistry, Amphipathic properties, synthesis of amino acids by reductive amination, C₄ and C₃ pathways and transamination.

Structure of proteins : Primary, secondary, tertiary, quaternary structure, reverse turn and Ramchandran Plot, protein stability : electrostatic forces, hydrogen bonding, disulfide bonding and hydrophobic interaction.

Enzymes : Structure and properties, substrate specificity, classification and mechanism of enzyme action.

Unit II

Carbohydrates : Classification, structure and function of monosaccharides, disaccharides and polysaccharides including starch, cellulose and pectin.

Photosynthesis : Photosynthesis, light reactions, absorption and transmission of light, energy, photo-oxidation, four complexes of

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Thylakoid membranes - photosystem I, photosystem II, photosystem 0, b₆/f complex, photosystem II and cytochrome b₆/f complex, water and O₂ evolution, non-cyclic and cyclic electron transport, water-water cycle, proton gradient and photophosphorylation, Calvin cycle, regulation of RuBisCO activity, control of photorespiration, C₄ pathway and its adaptive significance, CAM pathway, similarities between C₃ and C₄ plants, glycolysis pathway, anaerobic respiration, chlororespiration and C₂ concentrating mechanism in micro-organisms.

Glycolysis

Respiration : Anaerobic and aerobic respiration, amphibolic nature of TCA cycle, pentose phosphate pathway, glyoxylate pathway, oxidative phosphorylation, electron transport chain, high energy compounds : their synthesis and utilization.

Fat metabolism : synthesis of long chain fatty acids, lipid biosynthesis, and oxidation.

Secondary metabolites : Phytoalexins, production of secondary metabolites with special reference to terpenoids, alkaloids and steroids.

Plant growth regulators : Auxins, gibberellins, brassinolide, bioassay, physiological effects and mode of action.

Gibberellins - chemical nature, biosynthesis, physiological effects and mode of action.

Cytokinin - chemical nature, biosynthesis, physiological effects and mode of action.

Abscisic acid - chemical nature, biosynthesis, physiological effects and mode of action.

Physiology of flowering : Photoperiodism and vernalization.

Suggested Readings :

1. Buchanan, B.B., Griseb, W. and Jones, R.L. (2006). Biochemistry and Molecular Biology of Plants. American Society of Plant Physiologists, Maryland, USA.
2. Dennis, D.T., Pridmore, T.R., Schaffer, W. and Layzell, D.B. (Eds) 1997. Plant Metabolism (second edition). Longman Essex, England.
3. Galston, A.W. 1989. Life Processes in Plants. Scientific American Library. Springer-Verlag, New York, USA.

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Hoyer, P. H., H. A. and Johnson, K. R. (eds) 1970
 Biochemistry of Plant Hormones
 Academic Press, New York
 Hoyer, P. H. (ed) 1971
 Introduction to Plant Physiology, 10th
 Wiley, New York
 Lodish, H. D. and Baltimore, D. (eds) 1996
 Molecular Cell Biology (4th edn)
 W. H. Freeman, New York, USA
 Madsen, P. (ed) 1990
 Plant Physiology and Biochemistry
 Chapman and Hall, London
 Schaffer, W. D. (ed) 1977
 Plant Physiology, 2nd edn
 McGraw-Hill, New York
 Smith, G. O. (ed) 1974
 Plant Physiology, 2nd edn
 McGraw-Hill, New York
 Steward, R. C. (ed) 1971
 Plant Physiology, 2nd edn
 McGraw-Hill, New York
 Taiz, L. and Zeiger, E. (eds) 1991
 Plant Physiology, 3rd edn
 W. H. Freeman, New York
 Taiz, L. and Zeiger, E. (eds) 1994
 Plant Physiology, 4th edn
 W. H. Freeman, New York
 Taiz, L. and Zeiger, E. (eds) 1998
 Plant Physiology, 5th edn
 W. H. Freeman, New York
 Taiz, L. and Zeiger, E. (eds) 2004
 Plant Physiology, 6th edn
 W. H. Freeman, New York
 Taiz, L. and Zeiger, E. (eds) 2010
 Plant Physiology, 7th edn
 W. H. Freeman, New York
 Taiz, L. and Zeiger, E. (eds) 2015
 Plant Physiology, 8th edn
 W. H. Freeman, New York
 Taiz, L. and Zeiger, E. (eds) 2019
 Plant Physiology, 9th edn
 W. H. Freeman, New York
 Taiz, L. and Zeiger, E. (eds) 2023
 Plant Physiology, 10th edn
 W. H. Freeman, New York

1. To determine the effect of concentration on the rate of photosynthesis.
2. To determine the effect of light intensity on the rate of photosynthesis.
3. To determine the effect of temperature on the rate of photosynthesis.
4. To determine the effect of CO₂ concentration on the rate of photosynthesis.
5. To determine the effect of chlorophyll a, chlorophyll b, ratio of a and b, plants.
6. Isolation of intact chloroplasts and estimation of chloroplast protein content.
7. To determine the effect of light on in intact chloroplasts, to solve the components by SDS-PAGE and autoradiography.

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8. Extraction of seed proteins depending upon the solubility.
9. Determination of amoniacal nitrogenase activity, by effects and sensitivity of inhibitors.
10. Detailing of protein by gel filtration chromatography employing Sephadex.
11. Preparation of the standard of bovine serum albumin (BSA) and estimation of amoniacal nitrogenase activity by Lowry's or Bradford's method.
12. Fractionation of proteins by ion exchange chromatography by Sephadex (G100).
13. SDS-PAGE for estimation of proteins extracted from the given plant materials and comparison of their profile by staining with Coomassie Brilliant Blue G250.
14. Separation of isoenzymes of aspartate aminotransferase by native polyacrylamide.
15. Radioisotope method for estimation of protein activity, instrumentation (GM count rate) and principles involved.
16. Principles of colorimetry, fluorescence and fluorimetry.

Suggested Reading on Enzymology

1. Bajracharya, B. 1977. *Enzymology and Plant Physiology* : A Laboratory Manual. New Delhi, India.
2. Cooper, T.G. 1974. *Enzymology and Plant Physiology*. New York, USA.
3. Copeland, R.A. 1974. *Enzymology and Plant Physiology* : A Practical Approach. John Wiley & Sons, New York.
4. Dennison, C. 1979. *Enzymology and Plant Physiology*. Academic Publishers, London.
5. Devi, P. 2000. *Enzymology and Plant Physiology*. Molecular Biology. Biochemistry and Biotechnology, Jaipur, India.
6. Dryer, R.L. and Lutz, J. 1974. *Enzymology and Plant Physiology*. Oxford University Press, Oxford, U.K.
7. Haines B.D. (Ed) 1974. *Enzymology and Plant Physiology* : A Practical Approach. John Wiley & Sons, Oxford University Press, Oxford, U.K.
8. Harborne, T.C. 1981. *Phytochemical Methods : A Guide to Modern Techniques of Plant Analysis*. Chapman & Hall, London.

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body specificity, monoclonal antibodies and their uses, antibody engineering, antibody types of vaccines, preliminary account of Biofilms, Biofilms, Bioenzymes and Bioinsecticides.

Unit-III

Plant Pathology

6. History and scope of plant pathology. General account of diseases caused by plant pathogens. Pathogen attack and defense mechanisms. Physical, physiological, biochemical and molecular aspects.

Plant disease management: Chemical, biological, IPM systems, development of transgenics, biopesticides and disease clinics. Preliminary account of application of biotechnology in plant pathology.

Unit-IV

Symptomatology, identification and control of following plant diseases:

Rust of wheat (Tilletia), Rust of Sunflower (Cercospora), ergot and smut (Ustilago).

Red rot (Colletotrichum), Cotton (Wilt), Grapes (Downy mildew and powdery mildew).

Bacterial blight of wheat (Tilletia), Citrus blight.

Viral diseases: Tobacco mosaic, Bacterial yellow mosaic, Phytophthora blight. Little leaf of citrus.

Nematode disease: Root-knot of vegetables.

Suggested Readings:

1. Alexander, M. L., C.W. and Sargent, J. 1996. Insect diseases of plants. Wiley & Sons, Inc.
2. Agrios, G. N. 1990. Plant Pathology, 3rd Edition. Elsevier, Amsterdam.
3. Alexopoulos, C. E., M. M. Mims, Van Lanen, J. N. and Burdick, N. 2000. Rice, Insect and Disease Management in Crochman's Crop Protection Handbook.
4. Bridgman, J. C., D. & Scott, P. 1997. Information Technology: Plant Pathology and Biotechnology. CAB International, U.K.
5. Chittur, S. 1992. Introduction to the Bacteria. McGraw Hill Book Co., New York.
6. Mansour, M. 1994. Introduction to plant viruses. Chand & Co. Ltd. Delhi.

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Mehrotra R.S. B.A., B.Sc. (Hons.), M.A., Ph.D. (Hons.),
Ganga Ram Basu G. B. Ph.D. (Hons.)
1961 14th Edition
1973 2nd Edition
1981 3rd Edition
1984 4th Edition
1987 5th Edition
1990 6th Edition
1993 7th Edition
1996 8th Edition
2000 9th Edition
2004 10th Edition
2008 11th Edition
2012 12th Edition
2016 13th Edition
2020 14th Edition
GHS Publisher
New Delhi

1. Introduction
2. History of Microbiology
3. Microorganisms and their characteristics
4. Microorganisms and their uses

5. Microorganisms and their growth
6. Microorganisms and their control
7. Microorganisms and their application
8. Microorganisms and their relationship with environment
9. Microorganisms and their relationship with human health
10. Microorganisms and their relationship with industry

11. Microorganisms and their relationship with agriculture
12. Microorganisms and their relationship with medicine
13. Microorganisms and their relationship with food and nutrition
14. Microorganisms and their relationship with environment

15. Microorganisms and their relationship with industry
16. Microorganisms and their relationship with agriculture
17. Microorganisms and their relationship with medicine
18. Microorganisms and their relationship with food and nutrition
19. Microorganisms and their relationship with environment

20. Microorganisms and their relationship with industry
21. Microorganisms and their relationship with agriculture
22. Microorganisms and their relationship with medicine
23. Microorganisms and their relationship with food and nutrition
24. Microorganisms and their relationship with environment

25. Microorganisms and their relationship with industry
26. Microorganisms and their relationship with agriculture
27. Microorganisms and their relationship with medicine
28. Microorganisms and their relationship with food and nutrition
29. Microorganisms and their relationship with environment

30. Microorganisms and their relationship with industry
31. Microorganisms and their relationship with agriculture
32. Microorganisms and their relationship with medicine
33. Microorganisms and their relationship with food and nutrition
34. Microorganisms and their relationship with environment

Plant Pathology I

Basal as required for exam.

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Skeleton Paper

B.Sc. (Previous) Group-I Practical Examination

Time : 6 Hours

Q.No.	Questions	Marks
1.	(a) Perform the given molecular biology exercise. 16	
	(b) Perform the given exercise of cell biology molecular biology. 15	
2.	(a) Perform the given exercise of Cell Biology. 16	
	(b) Perform the given exercise of Cell Biology. Polyacrylamide gels. 16	
3.	(i) Identify the dye from the given table. Draw labelled diagrams. Deduce the significant characters and system. 2	
	(ii) Make a suitable preparation of <i>Salmonella typhi</i> show reproductive parts of the bacterium. 3	
	(iii) Draw well-labelled diagrams of <i>Salmonella typhi</i> giving reasons. 3	
	(iv) Make a suitable preparation of <i>Salmonella typhi</i> reproductive parts of the bacterium. Label the parts. Write down the significant characters. 3	
4.	Identify the material biologically (10)	

Skeleton Paper

B.Sc. (Previous) Group-II Practical Examination

Time : 6 Hours

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Q.No.	Questions	Marks
1.	(a) Describe the material in the given table. Assign it to the relevant family and give its new local diagram. 9	

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- (b) Prepare an artificial key of the given plant materials (A, B & C) 6
- (c) Make a suitable preparation of material 'D' 6

special interest, if any.

(d) Make a suitable preparation of given material 'E' (reproductive part only) Draw labelled diagram. Identify & give reasons. 6

Perform the physiology experiments as assigned to you. Describe the methodology and record your observations.

Exercise 'a' 20
Exercise 'b' 10

- (i) Perform the microbiological exercise given to you. Draw suitable diagram describe methodology and record your observations. 10
- (ii) Prepare a suitable slide of the given microbiological exercise. Draw diagram, describe methodology and record your results. 7
- (iii) Prepare a suitable slide of the given material for histological study. Draw diagram and record your observations.

Reference Books

Vijaya

Diploma	Microbiology
Paper-VI	: Plant Pathology
Paper-VII	: Plant Pathology
Paper-VIII	: Plant Pathology
Paper-IX	: Plant Pathology - Utilization and Conservation
Paper-X	: Biotechnology and Genetic Engineering of Plant and Animals
Paper-XI(a)	: Advanced Plant Pathology-I
Paper-XI(b)	: Advanced Plant Pathology-II
Paper-XI(c)	: Seed Science and Technology-I
Paper-XI(d)	: Seed Science and Technology-II

Excluded

Paper-XI(e)	: Revision of Plant Pathology
Paper-XI(f)	: Revision of Plant Pathology
Paper-XI(g)	: Revision of Plant Pathology
Paper-XI(h)	: Revision of Plant Pathology
Paper-XI(i)	: Revision of Plant Pathology
Paper-XI(j)	: Revision of Plant Pathology
Paper-XI(k)	: Revision of Plant Pathology
Paper-XI(l)	: Revision of Plant Pathology
Paper-XI(m)	: Revision of Plant Pathology
Paper-XI(n)	: Revision of Plant Pathology
Paper-XI(o)	: Revision of Plant Pathology
Paper-XI(p)	: Revision of Plant Pathology
Paper-XI(q)	: Revision of Plant Pathology
Paper-XI(r)	: Revision of Plant Pathology
Paper-XI(s)	: Revision of Plant Pathology
Paper-XI(t)	: Revision of Plant Pathology
Paper-XI(u)	: Revision of Plant Pathology
Paper-XI(v)	: Revision of Plant Pathology
Paper-XI(w)	: Revision of Plant Pathology
Paper-XI(x)	: Revision of Plant Pathology
Paper-XI(y)	: Revision of Plant Pathology
Paper-XI(z)	: Revision of Plant Pathology

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& REPRODUCTIVE BIOLOGY

Unit I

Introduction: Unique features of plant development, differences between animal and plant development

Seed germination and seedling growth: Metabolism of proteins and mobilization of food reserves, tropisms during seed germination and seedling growth, hormonal control of seedling growth, gene expression, use of mutants in understanding seedling development.

Shoot development: Organization of the shoot apical meristem (SAM), cytological and molecular analysis of SAM, control of cell division and cell to cell communication, Primary and Secondary tissue differentiation, control of tissue differentiation, especially xylem and phloem, secretory ducts and laticifers, wood development in relation to environmental factors.

Unit II

Leaf growth and differentiation: Inception, phyllotaxy, control of leaf form (leaf meristems and other factors), differentiation of epidermis (with special reference to stomata and trichomes) and mesophyll, Kranz anatomy, Leaf traces and leaf gaps, transfer cells.

Root development: Organization of root apical meristem (RAM), vascular tissue differentiation, lateral roots, root hairs, root-microbe interactions.

Seed coat development: External and internal morphology of seed, seed appendages, ontogeny of seed coat in various families, mature structure, spermoderm patterns.

Unit III

Reproduction : Vegetative options and sexual reproduction, flower development, genetics of floral organ differentiation, homeotic mutants in Arabidopsis and Antirrhinum, sex determination.

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Male gametophyte : Structure of anthers, microsporogenesis, role of tapetum, pollen development and gene expression, male sterility, sperm dimorphism and hybrid seed production, pollen germination, pollen tube growth and guidance, pollen storage, pollen allergy, pollen embryos.

Female gametophyte : Ovule development, megasporogenesis, organization of the embryo sac, structure of the embryo sac cells.

Pollination, pollen-pistil interaction and fertilization : Floral characteristics, pollination mechanisms and vectors, structure of the pistil, pollen-stigma interactions, sporophytic and gametophytic self-incompatibility (cytological, biochemical and molecular aspects), double fertilization, in vitro fertilization.

Unit IV

Seed development and fruit growth : Endosperm development, embryogenesis, cell lineages during late embryo development, storage proteins of endosperm and embryo

Polyembryony, apomixis, embryo culture, dynamics of fruit growth, biochemistry and molecular biology of fruit maturation.

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 the life cycle of plants, metabolic changes associated with senescence and its regulation, influence of hormones and environmental factors on senescence.

Suggested Readings:

2. Bewley, J.D. and Black, M. 1994. Seeds: Physiology of Development and Germination, Plenum Press, New York.
3. Burgess, J. 1985. An Introduction to Plant Cell Development. Cambridge University Press, Cambridge.
4. Fahn, A. 1982. Plant Anatomy. (3rd edition). Pergamon Press, Oxford.
New York.
10. Raven, P.H., Evert, R.F. and Eichhorn, S. 1992. Biology of Plants (5th edition). Worth, New York
11. Salisbury, P.B. and Ross, C.W. 1992. Plant Physiology (4th edition). Wadsworth Publishing, Belmont, California.

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- Cambridge University Press, Cambridge.
13. Bhojwani, S.S. and Bhatnagar, S.P. 2000. The Embryology of Angiosperms (4th revised and enlarged edition). Vikas Publishing House, New Delhi.
 14. Fosker, D.E. 1994. Plant Growth and Development. A Molecular Approach. Academic Press, San Diego.
 15. Howell, S.H. 1998. Molecular Genetics of Plant Development. Cambridge University press, Cambridge.
 16. Leins, P., Tucker, S.C. and Endress, P.K. 1988. Aspects of Floral Development, J. Cramer, Germany.
 17. Lyndon, R.F. 1990. Plant Development. The Cellular Basis, Unwin Hyman, London.
 18. Murphy, T.M. and Thompson, W.E, 1988. Molecular Plant Development. Prentice Hall, New Jersey.
 19. Proctor, M. and Yeo, P. 1973. The Pollination of Flowers. William Collins Sons, London.
 20. Raghavan, V. 1997. Molecular Embryology of Flowering Plants. Cambridge University Press, Cambridge.
 20. Raghavan, V. 1997. Molecular Embryology of Flowering Plants. Cambridge University Press, Cambridge.
 20. Raghavan, V. 1997. Molecular Embryology of Flowering Plants. Cambridge University Press, Cambridge.
 21. Raghavan, V. 1999. Developmental Biology of Flowering Plants. Springer-Verlag, New York.
 22. Sdgely, M. and Griffin, A.R. 1989. Sexual Reproduction to Tree Crops. Academic Press, London.
 23. Shivanna, K.R. and Sawhney, V.K. (eds.) 1997. Pollen Biotechnology for Crop Production and Improvement. Cambridge University Press, Cambridge.
 24. Shivanna, K.R. and Rangaswamy, N.S. 1992. Pollen Biology : A Laboratory Manual. Springer-Verlag, Berlin.
 25. Shivanna, K.R. and Johri, B.M. 1985. The Angiosperm Pollen : Structure and Function. Wiley Eastern Ltd., New York.
 26. The Plant Cell Special Issue on Reproductive Biology of Plants. Vol. 5(10) 1993.

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Suggested Laboratory/Field Exercises

1. Study of living shoot apices by dissections using plants such as *Tabernaemontana*, *Albizia*
2. Study of cytohistological zonation in the shoot apical meristem (SAM) in sectioned and double-stained permanent slides of a suitable plant. Examination of shoot apices in a monocotyledon in both T.S. and L.S. to show the origin and arrangement of leaf primordia.
3. Study of alternate and distichous, alternate and superposed, opposite and superposed, opposite and decussate leaf arrangement. Examination of rosette plants (*Launaea*, *Mollugo*, *Raphanus*, *Hyoscyamus* etc.) and induction of bolting under natural conditions as well as by GA treatment.
4. Microscopic examination of vertical sections of leaves such as *Eucalyptus*, *Ficus*, *Mango*, *Nerium*, maize, grass and wheat to understand the internal structure of leaf tissues and trichomes, glands etc. Also study the leaf anatomy C3 and C4 of plants.
5. Study of epidermal peels of leaves such as *Coccinia*, *Tradescantia* etc. to study the development and final structure of stomata and prepare stomatal index.
6. Study of types of stomata in plants belonging to different families.
7. Study of whole roots in monocots and dicots.
8. Examination of L.S. of root from a permanent preparation to understand the organization of root apical meristem and its derivatives. (use maize, aerial roots of banyan etc.)
9. Study of lateral root development.
10. Study of leguminous roots with different types of nodules.
11. Study of primary and secondary tissue differentiation in roots and shoots.
12. Study of seed coat types- *Pisum*, *Cucurbita*, wheat.
13. Study of vascular tissues by clearing technique
14. Study of microsporogenesis and gametogenesis in sections of anthers of different ages.
15. Examination of modes of anther dehiscence and collection of pollen grains for microscopic examination (maize, grasses, *Cannabis sativa*, *Crotolaria*, *Tradescantia*, *Brassica*, *Petunia*, *Solanum melongena*, etc.)
16. Study of wall layers of anther.
17. Tests for pollen viability using stains and in vitro germination.
18. Pollen germination using hanging drop and sitting drop cultures, suspension culture and surface culture.

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