

**UNIVERSITY OF RAJASTHAN**  
**JAIPUR**

**SYLLABUS**

**M.Sc. BOTANY**

**(ANNUAL SCHEME)**

**M.Sc. (Previous) Examination 2018**

**M.Sc. (Final) Examination 2019**

*Dy. Registrar*  
**(Academic)**  
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M.Sc. (BOTANY)  
M. Sc. (ANNUAL PATTERN)

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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 XII (c) : Environmental 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. Botany  
Scheme of Examination

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.

M.Sc. Botany  
Scheme of Examination

M.Sc. (Prev.)

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 several short objective type of questions such as multiple choice type, one line answer type, one word type and fill in the blanks type.  
M.Sc. (Final) with a limit of 200 marks.

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 6 hours duration to be completed in two days.

(ii) Practical for elective papers of 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 several short objective type of questions such as multiple choice type, one line answer type, one word type, fill in the blanks type.

M.Sc. Previous

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

Paper-I : Cell and Molecular Biology of Plants

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 com-

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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 cell types, chemical foundation, biochemical

Cell wall: Structure and functions, growth, growth

Plasma membrane: Structure, models and functions, sites for

ATPase, ion carrier, channels and pumps, receptors.

Plasmodesma: Structure, role in movement of molecules and

molecules, comparison with gap junctions.

Unit-II

Chloroplast: Structure, genome organization, gene expression,

RNA editing, nucleolar protein synthesis.

Mitochondria: Structure, genome organization, bioenergetics,

Plant vacuole: Tonicoplast membrane, ATPase, transporters, as

storage organelle.

Nucleus: Structure, nuclear pores, nucleosome organization,

DNA structure, A, B and Z forms, replication, damage and repair,

mRNA transport functions, RNA processing.

Restriction enzymes: Cleavage of DNA into specific fragments,

transformation of a restriction map from the fragments, trans-

formation, as genetic markers, RFLP and their role in plant breeding.

Unit-III

Ribosome: Structure, site of protein synthesis, mechanism of

translation, initiation, elongation and termination, structure and role

of RNA.

Targeting of proteins to organelles

Cell shape and motility: The cytoskeleton, organization and

role of microtubules and microfilaments; motor proteins, implica-

Unit-IV

Cell cycle and apoptosis: Control mechanisms, role of cyclins

and cyclin-dependent kinases, retinoblastoma and p53 proteins,

cytokinesis and cell plate formation, mechanisms of programmed

cell death.

Other Cellular organelles: Structure and functions of

microbodies, Golgi apparatus, lysosomes, endoplasmic reticulum.

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

*Suggested Readings:*

1. Lewin, B. 2000. Genes VII. 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. 1993. Molecular and Cellular Biology. Wadsworth Publishing USA.
4. Rost, T., *et al.* 1998. Plant Biology. Wadsworth Publishing Co., California USA.
5. Krishnamurthy, K.V. 2000. Methods in Cell Wall Cytochemistry. CRC Press, Boca Raton, Florida.
6. Buchanan, B.B., Grulisek, W. and Jones, R.L. 2000. Biochemistry and Molecular Biology of Plants. American Society of Plant Physiologists Maryland, USA.
7. De, D.N. : 2000. Plant Cell Walls: An Introduction. CSIRO Publication Collingwood, Australia.
8. Kleinsmith, L.J. and Keith, V.M. 1995. Principles of Cell and Molecular Biology (2nd Edition). Harper Collins College Publishers, New York USA.
9. Lodish, H., Berk, A., Zipursky, S.L., Matsudaira, P., Baltimore, D. and Darnell, J. 2000. Molecular Cell Biology (4th Edition). W.H. Freeman and Co., New York, USA.

*See the following Review Journals*

Annual Review of Plant Physiology and Molecular Biology.  
Current Advances in Plant Sciences.  
Trends in Plant Sciences.  
Nature Reviews : Molecular and Cell Biology.

*Suggested Laboratory Exercises*

1. Isolation of mitochondria and the activity of its marker enzyme, succinate dehydrogenase (SDH).
2. Isolation of chloroplasts and SDS-PAGE profile, of proteins to demarcate the two subunits 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 quantitation by a spectrophotometric method.
8. Separation of plant RNA by agarose gel electrophoresis and visualization by EIB staining.
9. Southern blot analysis using a gene specific probe.
10. Northern blot analysis using a gene specific probe.
11. Immunological techniques: Radioimmunoassay (RIA) and Enzyme-linked immunosorbent assay (ELISA) and staining with colloidal gold.
12. Fluorescence staining with FDA for cell viability and cell wall staining with calcofluor.
13. Demonstration of SEM and TEM.
14. Notes: Chemicals and kits for conducting some of the above molecular biology experiments are available in India, for example from VLSI Biotechnology Centre and Centre for Biotechnology (CSTRI), Madras, India.
15. **Selected readings (for laboratory exercises)**  
L. Goligorsky and Thompson, J.E. 1991. Methods in Plant Molecular Biology and Biotechnology. CRC Press, Boca Raton, Florida.
16. Glover, D.M. and Hains, B.D. (Eds.) 1995. DNA Cloning 2: A Practical Approach. Core techniques, 2nd edition. IASBRI, Oxford University Press, Oxford.
17. Gunning, B.E.S. and Iqbal, M.A. 1996. Plant Cell Biology: Structure and Function. Jones and Bartlett Publishers, Boston, Massachusetts.
18. Hickey, P.B., Puchs, J. and Messing, J.W. 1982. *Arabidopsis thaliana*: A Laboratory Handbook. Academic Press, London, UK.
19. Hall, J.E. and Moore, A.L. 1983. Isolation of Membranes and Organelles from Plant Cells. Academic Press, London, UK.
20. Hattori, N. and Oparil, N.J. 1994. Plant Cell Biology: A Practical Approach. IRL Press, at Oxford University Press, Oxford.
21. Shaw, G.H. (Ed.) 1988. Plant Molecular Biology 1: A Practical Approach. IRL Press, at Oxford University Press, Oxford.



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Genetic recombination and gene amplification  
tion, silencing and activation  
prokaryotes and eukaryotes. Family of genes, catalytic sites  
significance, RNA splicing, regulation of gene expression in  
trans test, fine structure analysis of eukaryotes, amino acid  
Gene Structure and expression: Gene structure, genetic dis-  
crete entities  
in bacteria, genes of mitochondria and chloroplasts, cytoplasmic  
nucleon in phage, genetic transformation, conjugation and transduc-  
tion, the bacteriophage lambda, phage mutants, genetic control of  
Genetics of prokaryotes and eukaryotes, and mutants of DNA

GENETICS  
Part II

and monosomes  
tion of major crop plants, production and inheritance of homozy-  
gous allopolyploids, D.P.C. of chromosomes and analysis, evolu-  
tion, production of aneuploids, chromosome and chromatin struc-  
ture and meiosis of haploids, aneuploids and euploids, origin and  
action and translocation, eukaryotes, origin of centromeres, poly-  
geny, meiosis and breeding behaviour of diploids, tetraploids and  
Structural and numerical alterations in chromosomes: On-  
some pairing  
B-chromosomes and sex-chromosomes, molecular basis of chromo-  
somal evolution, specialized D.P.C. of chromosomes, polyploidy, hybridity,  
heterochromatin, karyotype analysis, banding patterns, karyotype  
nucleolus and ribosomal RNA genes, euchromatin and  
ing of DNA, molecular organization of eukaryotes and prokaryotes  
Chromatin organization: Chromosome structure and packing

CYTOLOGY

with a limit of 2000 words  
Each paper will have 9 questions, out of which 5 questions to  
attempt 5 questions including the question No. 1 which will be com-  
pulsory. The question No. 1 will carry 20 marks and will be of  
short answer type. The questions No. 2 to 9 will be of  
essay type. The questions No. 2 to 9 will carry 20 marks each. The  
total marks will be 100.

Scheme of Examination  
Paper II - Cytology, Genetics and Evolution  
Approach: ILL Press, Oxford  
University of Rajasthan

independent assortment and crossing over, molecular mechanism of recombination, role of RecA and RecBCD enzymes, site specific recombination, chromosome mapping, linkage groups, genetic markers, construction of molecular maps, correlation of genetic and physical maps, somatic cell genetics, an alternative approach in gene mapping.

### Unit-III CYTOGENETICS

Mutagens: Spontaneous and induced mutagens, physical and chemical mutagens, molecular basis of gene mutation, transposable elements in prokaryotes and eukaryotes, mutation induced by transposons, site directed mutagenesis, DNA damage and repair mechanisms, inherited diseases and defects in DNA repair, mutation of cancer at cellular level, protooncogenes and oncogenes.

Sex determination, sex linked inheritance, sex limited characters and sex reversal, multiple alleles and blood groups in man.

Cytogenetics of autopolyploids and structural heterozygotes. Effect of aneuploidy on phenotype in plants, transmission of monosomies and trisomies and their use in chromosome mapping in diploid and polyploid species, breeding behaviour and effects of structural heterozygotes, complex translocation heterozygotes, translocation carrier sets, Robertsonian translocations, B-A translocations.

### Unit-IV

Molecular cytogenetics: Nuclear DNA content, C-banding, FISH, G-banding, R-banding, fluorescence, restriction mapping, Southern blot techniques, DNA probes and their applications in cytogenetics, copy number techniques, physical mapping of genes on chromosomes, computer assisted chromosome analysis, value based identification and classification, flow cytometry and confocal microscopy in cytotype analysis.

Alien gene transfer through chromosome manipulations, Transfer of whole genome, examples from wheat, maize and rice, transfer of individual chromosomes and chromosome segments, methods for detecting alien chromatin, reproductive characteristics and utility of alien addition and substitution lines, genetic basis of inbreeding and heterosis, exploitation of hybrid vigour.

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*Suggested Readings*

1. Alberts, B., Bray, D., Lewis, J., Raff, M., Roberts, K. and Watson, J.D. 1989. *Molecular Biology of the Cell* (2nd edition), Garland Publishing Inc., New York.
2. Atherly, A.G., Gorton, J.R. and McDonald, J.F. 1999. *The Science of Genetics*. Saunders College Publishing, Port Worth, USA.
3. Burnham, C.R. 1962. *Discussions in Cytogenetics*. Burgess Publishing Co. Minnesota.
4. Busch, H. and Rothblum, L. 1982. Volume X. *The Cell Nucleus rDNA Part A*. Academic Press.
5. Hartl, D.L. and Jones, E.W. 1998. *Genetics: Principles and Analysis* (4th edition). Jones & Bartlett Publishers, Massachusetts, USA.
6. Khush, G.S. 1973. *Cytogenetics of Aneuploids*. 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*. Oxford University Press, New York, USA.
9. Lewis, R. 1997. *Human Genetics: Concepts and Applications* (2nd edition). WCB, McGraw Hill, USA.
10. Malacinski, G.M. and Freifelder, D. 1998. *Essentials of Molecular Biology* (3rd edition). Jones and B. Arlet Publishers, Inc., London.
11. Ruvet, P.J. 1998. *Genetics* (5th edition). The Benjamin/Cummings Publishing Company Inc., USA.
12. Snustad, D.P. and Simmons, M.L. 2000. *Principles of Genetics* (2nd edition). John Wiley & Sons, Inc., USA.

*Suggested Laboratory Exercises*

1. Linear differentiation of chromosomes through banding techniques, such as G-banding, C-banding and Q-banding.
2. Silver banding for staining nucleolus organizing region, where 18S and 28S rDNA are transcribed.
3. Orcein and Feulgen. Staining of the salivary gland chromosomes of *Chironomas* and *Drosophila*.
4. Characteristics and behaviour of B chromosomes using maize or any other appropriate material.
5. Working out the effects of mono- and tri-sony on plant pheno-

- type, fertility and meiotic behaviour.
6. Induction of polyploidy using colchicines, different methods of the application of Colchicines.
7. Effect of induced and spontaneous polyploidy on plant phenotype, meiosis, pollen and seed fertility and fruit set.
8. Effect of translocation heterozygosity on plant phenotype, chromosome pairing and chromosome disjunction 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.

**Suggested Readings :**

1. Fukui, K. and Nakayama, S. 1996 : Plant Chromosomes : Laboratory Methods, CRC Press, Boca Raton, Florida.
2. Sharma, A.K. and Sharma, A. 1999. Plant Chromosome Analysis : Manipulation and Engineering. Harwood Academic Publisher, Australia.

**Paper-III : Biology and Diversity of Lower Plants :  
Cryptogams**

**Scheme of Examination** **Max Marks : 100**

Each paper will have 9 questions, out of which a student has to attempt 5 questions including the question No.1 which will be compulsory. The question No.1 will carry 20 marks and will be of short answer objective type of questions such as multiple choice type, true and false, yes/no, word type and fill in the blank type. The limit of the words will be -

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

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Central Book Depot, Allahabad.

Puri, P. 1930. Bryophytes. Atma Ram & Sons, Delhi.

Rangaswamy, G. and Mahadeva, A. 1999. Diseases of Crop Plants in India (4th edition). Prentice Hall of India Pvt. Ltd., New Delhi.

Round, F.E. 1936. The Biology of Algae. Cambridge University Press, Cambridge.

Sporne, K.K. 1991. The Morphology of Pteridophytes. B.L. Publishing Pvt. Ltd., Mumbai.

Stewart, W.N. and Rathwell, G.W. 1993. Paleobotany and the Evolution of Plants. Cambridge University Press.

Webster, J. 1985. Introduction to Fungi. Cambridge University Press.

**Suggested Laboratory Exercises**

Morphological study of representative members of algae, fungi, bacteria, bryophytes and pteridophytes: *Microcystis*, *Aulosira*, *Oocystis*, *Pediastrum*, *Hydrocoleum*, *Ulva*, *Pyrothopora*, *Stigeoclonium*, *Desmarestia*, *Chlorella*, *Coscinodiscus*, *Chlorella*, *Stemonitis*, *Chlorella*, *Albugo*, *Mucor*, *Pilobolus*, *Yeast*, *Emericella*, *Chaetomium*, *Pleurozia*, *Marchelia*, *Melampsora*, *Phallus*, *Polyporus*, *Drochsteia*, *Fuaria*, *Penicillium*, *Aspergillus*, *Colletotrichum*, *Marthania*, *Anthoceros*, *Polypodium*, *Psidium*, *Lycopodium*, *Selaginella*, *Equisetum*, *Gleichenia*, *Pteris*, *Ophioglossum*, *Isetes*.

Symptomatology of some diseased specimens: White rust, downy mildew, powdery mildew, rusts, smuts, ergot, groundnut leaf spot, red rot of sugarcane, blights, paddy blast, coffee canker, bacterial blight of paddy, angular leaf spot of cotton, tobacco mosaic, little leaf of brinjal, stemphyliosis, mango malformation.

Study of morphology, anatomy and reproductive structures of bryophytes and pteridophytes.

Gram staining of bacteria.

Identification of fungal cultures: *Rhizopus*, *Mucor*, *Aspergillus*, *Penicillium*, *Emericella*, *Chaetomium*, *Drochsteia*, *Phoma*, *Fusicladium*, *Phoma*, *Colletotrichum*, *Graphium*.

Preparation of media and stains.

Study of the economy and diversity of Seed Plants.

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## PAPER IV: 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 Molitra, 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 21<sup>st</sup> 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. Gebrüder Borntraeger, 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) Cappariidaceae, (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 Apiaceae, (16) Rubiaceae, (17) Asteraceae, (18) Primulaceae, (19) Plumbaginaceae, (20) Asclepiadaceae, (21) Convolvulaceae, (22) Solanaceae, (23) Boraginaceae, (24) Polemoniaceae, (25) Acanthaceae, (26) Pedaliaceae, (27) Martyniaceae, (28) Bignoniaceae, (29) Labiatae, (30) Nyctaginaceae, (31) Polygonaceae, (32) Chenopodiaceae, (33) Amaranthaceae, (34) Aizoaceae, (35) Molluginaceae, (36) Euphorbiaceae, (37) Commelinaceae and (38) 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.

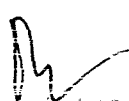
6. Location of key characters and use of keys at family level.

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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Handwritten notes and scribbles at the top of the page, including the word 'Kee' and some illegible text.

Chapter V: Plant Physiology and Metabolism  
 Scheme of Examination  
 Max. Marks : 100

Each paper will have 9 questions, out of which a student has to attempt 5 questions including the question No. 1 which will be compulsory. The question No. 1 will carry 20 marks and will be of short answer type. The questions are of multiple choice type and the answer type word and fill in the blank type.

Unit-I  
 Water relation of plants : Unique physicochemical properties of water, chemical potential, water potential, apparent free space, wilting, wilting coefficient, soil-plant-atmosphere continuum (SPAC), the movement of water, soil Plant Atmosphere Continuum (SPAC), stomatal regulation of transpiration, signal transduction in guard cells, active transport : passive - non-mediated transport and symport, passive-mediated transport, ATP-driven active transport, symport, antiport, channel proteins, Nod factor, root nodule formation, nitrogen fixation, structure of amino acids, stereo-isomerism, amino acids, synthesis of amino acids by reductive amination, GS-GOGAT system and transamination.

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

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

Unit-II  
 Carbohydrates : Classification, structure and function of polysaccharides, oligosaccharides and glycoproteins including starch, cellulose and glycans.

Formation of central energy, photo-oxidation, four complexes of photosynthesis, photochemical reactions, absorption and transmission of light energy.

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1. Butanan, R.B., Guistlin, W. and Ross, J.L. 2000. Biochem-  
istry and Molecular Biology of Plants. American Society of  
Plant Physiologists, Maryland, USA.  
2. Dennis, D.T., Turpin, D.A., Leebens, D.D. and Layzell, D.B.  
(Eds) 1997. Plant Metabolism (second edition). Longman Ex-  
sex, England.  
3. Gaisson, A.W. 1989. Life Processes in Plants. Scientific Ameri-  
can Library, Springer-Verlag, New York, USA.

**Suggested Readings:**

Plant growth regulator: Auxins - chemical nature, biosynthesis,  
physiological effects and mode of action.  
Gibberellins - chemical nature, biosynthesis, physiological effects  
and mode of action.  
Cytokinins - 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.

**UNIT-IV**

Respiration: Anaerobic and aerobic respiration, amphibolic  
nature of TCA cycle, pentose phosphate pathway, glycolytic path-  
way, oxidative phosphorylation, mitochondria, high energy com-  
pounds: their synthesis and utilization.  
Fat metabolism: Synthesis of long chain fatty acids, lipid  
biosynthesis, and oxidation.  
Secondary metabolites: Biosynthesis and function of second-  
ary metabolites with special reference to tannins, alkaloids and ster-  
oids.

**UNIT-V**

Photosynthesis: Light dependent reaction, photosystem I, photosystem II and coupling factors, photolysis of water and O<sub>2</sub>  
evolution, non-cyclic and cyclic transport of electrons, water  
water cycle, proton gradient and photophosphorylation, Calvin cycle,  
regulation of RUBISCO activity, control of Calvin cycle, C<sub>3</sub> pathway  
and its adaptive significance, CAM pathway, differences between C<sub>3</sub>  
and C<sub>4</sub> plants, glycolate pathway and photorespiration,  
chlororespiration and C<sub>2</sub> concentrating mechanism in micro-organ-  
ism.

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7. To determine the effect of chlorophyll a and chlorophyll b ratio in C<sub>3</sub> and C<sub>4</sub> plants.

6. Isolation of intact chloroplasts and estimation of chlorophyll content.

5. To determine the effect of chlorophyll a and chlorophyll b ratio in C<sub>3</sub> and C<sub>4</sub> plants.

4. Estimation of chlorophyll content from leaves and preparation of chlorophyll a and chlorophyll b standards.

3. Demonstration of the effect of light intensity on the rate of photosynthesis.

2. Effect of light intensity on the rate of photosynthesis (using redox potential).

1. Effect of light and carbon dioxide concentration on the rate of photosynthesis.

13. H. G. Callaway, ed. (1992) Molecular Plant Development from Genetic to Plant. Oxford University Press, Oxford, UK.

12. Weathill, J. (1992) Molecular Plant Development from Genetic to Plant. Oxford University Press, Oxford, UK.

11. Thomas, B. and Van der Plig, D. (1992) Photochemistry and Plant Growth. Academic Press, San Diego, USA.

10. S. G. Long, ed. (1992) Photosynthesis. Academic Press, San Diego, USA.

9. Govindjee (1992) Concepts in Photosynthesis. Elsevier, Amsterdam, The Netherlands.

8. Govindjee (1992) Concepts in Photosynthesis. Elsevier, Amsterdam, The Netherlands.

7. S. G. Long, ed. (1992) Photosynthesis. Academic Press, San Diego, USA.

6. S. G. Long, ed. (1992) Photosynthesis. Academic Press, San Diego, USA.

5. S. G. Long, ed. (1992) Photosynthesis. Academic Press, San Diego, USA.

4. S. G. Long, ed. (1992) Photosynthesis. Academic Press, San Diego, USA.

3. S. G. Long, ed. (1992) Photosynthesis. Academic Press, San Diego, USA.

2. S. G. Long, ed. (1992) Photosynthesis. Academic Press, San Diego, USA.

1. S. G. Long, ed. (1992) Photosynthesis. Academic Press, San Diego, USA.

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8. Extraction of seed proteins depending upon the solubility.
9. Determination of succinate dehydrogenase activity, its kinetics and sensitivity to inhibitors.
10. Desalting of proteins by gel filtration chromatography employing Sephadex.
11. Preparation of the standard curve of protein (BSA) and estimation of the protein content in extracts of plant material by Lowry's or Bradford's method.
12. Fractionation of proteins using gel filtration chromatography by Sephadex G100 or Sephadex G200.
13. SDS-PAGE for soluble proteins extracted from the given plant materials and comparison of their profile by staining with Coomassie Brilliant Blue or silver nitrate.
14. Separation of isozymes of esterase, peroxidases by native polyacrylamide gel electrophoresis.
15. Radioisotope methodology, autoradiography, instrumentation (GM count and Scintillation Counter) and principles involved.
16. Principles of colorimetry, spectrophotometry and fluorimetry.

*Suggested Readings (for laboratory exercise)*

1. Bajracharya, D. 1999. Experiments in Plant Physiology : A Laboratory Manual. Narosa Publishing House, New Delhi.
2. Cooper, T.G. 1977. *Abolant Biochemistry*. John Wiley, New York, USA.
3. Copeland, R.A. 1996. *Enzymes: A Practical introduction to Structure, Mechanism and Data Analysis*. VCH Publishers, New York.
4. Dennison, C. 1999. *A Guide to Protein Isolation*. Kluwer Academic Publishers, Dordrecht, The Netherlands.
5. Devi, P. 2000. *Principles and Methods of Plant Molecular Biology, Biochemistry and Genetics*. Anand Publishers, Jodhpur, India.
6. Dyer, R.L. and Lita, G.F. 1982. *Experimental Biochemistry*. Oxford University Press, New York.
7. Haines B.D. (Ed.) 1998. *Gel Electrophoresis of Proteins : A Practical Approach*, 3rd edition, PAS, 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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- Moore, T.G. 1974. Research Experiences in Plant Physiology: A Laboratory Manual. Springer-Verlag, Berlin.
10. Nisfa, A.F. and Ballou, D.P. 1998. Fundamental Laboratory Approaches for Biochemistry and Biotechnology. Fitzgerald Science Press, Inc. Maryland, USA.
11. Bunnell, D.L. 1994. An Introduction to Practical Biochemistry. Tata McGraw-Hill Publishing Co. Ltd, New Delhi.
12. Scott, R.A.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.

**Paper - II: Microbiology and Plant Pathology**

**Part of Examination**

Max. Marks: 100

Each paper will have 9 questions, out of which a student has to answer 5 questions including the question No. 1 which will be compulsory. The question No.1 will carry 20 marks and will be of an essay type. The other type of questions such as multiple choice type, one answer type, one word type and fill in the blanks type.

**Unit - I**

**Microbiology**

1. Important landmarks in the history of microbiology: Archaeobacteria and eubacteria: General account, ultrastructure, nutrition and reproduction, biology and economic importance, cyanobacteria: features and biological importance.
2. Viruses: Classification, characteristics and ultrastructure of virus, isolation and purification of viruses, chemical nature, replication, transmission of viruses, cyanophages, economic importance.
3. Phytoplasmids: General characteristics and role in causing plant diseases.

**Unit-II**

4. Scope and application of microbes in agriculture, industry, food, pollution and biological control of pests.
5. General account of immunity, allergy, properties of antigens and antibodies, antibody structure and function, affinity and anti-

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body specificity. Monoclonal antibodies and their uses, antibody engineering, serology, types of vaccines. Preliminary account of Biofilms, biochips, biosensors and bioactants.

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, plant disease clinics. Preliminary account of application of Biotechnology in plant pathology.

Unit-IV

Symptomology, identification and control of following plant diseases.

Fungal diseases : Wheat (Rust, Smut, Bunt), Bajra (Green ear, ergot and Smut), sorghum (rust).

Paddy (Paddy blast), Cotton (Wilt), Grapes (Downy mildew and powdery mildew).

Bacterial disease : Wheat (Tundu), Citrus canker.

Viral disease : Tobacco mosaic, Bhindi yellow mosaic.

Phytoplasma disease : Little leaf of brinjal.

Nematode disease : Root-knot of vegetables.

Suggested Reading

1. Alexopoulos, C.J., Mims, C.W. and Blackwell, M. 1996, Introductory Mycology, John Wiley & Sons Inc.
2. Agrios, G.N. 1997, Plant Pathology, Academic Press, London.
3. Albajes, R., Guillino, M.L., Van Lenteren, J.C. and Elad, Y. 2000, Integrated Pest and Disease Management in Greenhouse Crops, Kluwer Academic Publishers.
4. Bridge, P., Moore, D.R. & Scott, P.R. 1998, Information Technology, Plant Pathology and Biodiversity, CAB International, U.K.
5. Clifton, A. 1958, Introduction to the Bacteria, McGraw Hill Book Co. New York.
6. Mandharia, Ch. 1978, Introduction to plant viruses, Chand & Co. Ltd. Delhi.

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Plant Pathology  
Diseases as per ...

... by yeast, ... use of different  
substrates, e.g. glucose, fructose, amino-sugars, starch) (based on  
topic 8)

... on virus infected plants (symptoms) (based on topic  
... appearance, microscopic observations) (based on topic  
... on temperature, appearance of micro-organisms  
... of micro-organisms, columnar and rod-shaped  
... of standard error, ... (based on topic  
... relationship between dilution and cell count, determining  
... use of haemocytometer, serial dilution test  
... of microbial population size (suggested model  
...)

... principle of colony/plate count (based on  
... of micro-organisms, e.g. glucose, fructose, fr-  
... of growth of micro-organisms (model organism:  
...)

... isolation of micro-organisms, ... on plates 7 and  
... of growth, preservation (based on topics 7 and  
...)

... media for autotrophic and heterotrophic microor-  
... (chemical, physical, mineral media, complex me-  
...)

... of micro-organisms (suggested model of micro-organisms, e.g. yeast, lactobacilli,  
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... of micro-organisms, ... of dimensions of  
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M.Sc. (Previous) Group-I Practical Examination	
Skeleton Paper	
Time : 6 Hours	
MAY : 150	
Q.No.	Questions
Marks	Allocated
1	(a) Perform the given molecular biology exercise.
16	(b) Perform the given exercise of cell biology.
15	(a) Perform the given exercise of Genetics/Minors.
16	(b) Perform the given exercise of Cytogenetics.
16	(i) Identify two algae from the given picture. (A)
8	Draw labelled diagrams. Comment upon their significant characters and systematic.
8	(ii) Make a suitable preparation of material. Highlight
8	show reproductive parts of the fungus.
8	(iii) Draw well labelled diagrams. Identify the fungus giving reasons.
8	(iv) Make a suitable preparation of separate reproductive parts of the material. Draw labelled sketches. Write features of special interest and identify giving reasons.
18	Identify the spots critically (6x3)
22	Additional marks
15	Extra-1000
M.Sc. (Previous) Group-II Practical Examination	
Skeleton Paper	
Time : 6 Hours	
MAY : 150	
Q.No.	Questions
Marks	Allocated
1	(a) Describe the material in technical language. Assign it to the relevant family with reasons. Draw floral diagram.
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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'

special interest, if any. 10

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

2. 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 'D' for histological study. Draw labelled diagram. Identify the pathogen giving reasons. 12

Spots 60 78

Herbarium 5

Sessional Marks 22

Viva-voce 15

- Plant Morphology, Development & Reproduction*
- Paper-VII : Plant Development and Reproduction
  - Paper-VIII : Plant Ecology
  - Paper-IX : Plant Resource Utilization and Conservation
  - Paper-X : Biotechnology and Genetic Engineering of Plants and Microbes
  - Paper-XI(a) : Advanced Plant Pathology-I
  - Paper-XI(a) : Advanced Plant Pathology-II
  - Paper-XII(b) : Seed Science and Technology-I
  - Paper-XII(b) : Seed Science and Technology-II

- Ecosystem Ecology*
- Paper-XI(c) : Environmental Biology
  - Paper-XII(c) : Acid-Base Toxicology Environmental Biology
  - Paper-XI(d) : Advanced Plant Physiology-I
  - Paper-XI(d) : Advanced Plant Physiology-II
  - Paper-XI(e) : Advanced Morphology and Morphogenesis-I
  - Paper-XI(e) : Advanced Morphology and Morphogenesis-II
  - Paper-XI(f) : Biosystematics of Angiosperms-I
  - Paper-XI(f) : Biosystematics of Angiosperms-II
  - Paper-XI(g) : Biotechnology-I
  - Paper-XI(g) : Biotechnology-II

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(Acad.)

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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.

- Cambridge University Press, Cambridge.
13. Bhojwani, S.S. and Bhatnagar, S.P. 2000. The Embryology of Angiosperms (4<sup>th</sup> 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, VK. (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.

### 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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20. Study of ovules in cleared preparations, study of monosporic, bisporic and tetrasporic types of embryo sac development through examination of permanent, stained serial-sections.
21. Field study of several types of flower with different pollination mechanisms.
22. Emasculation, bagging and hand pollination to study pollen germination.
23. Study of nuclear and cellular endosperm through dissections and staining.
24. Isolation of zygotic globular, heart-shaped, torpedo stage and mature embryos from suitable seeds
25. Polyembryony in citrus, jamun (*Syzygium cumini*) etc. by dissections.
26. Biochemical estimation (qualitative and quantitative) of metabolites of seeds.

*Suggested Readings. (for Laboratory Exercises)*

1. Shivanna, K.R. and Rangaswamy, N.S. 1992. Pollen Biology : A Laboratory Manual, Springer-Verlag, Berlin-Heidelberg (and references therein).
2. Chopra, V.L. 2001. Plant Breeding : Theory and Practice. Oxford IBH Pvt. Ltd., New Delhi.
3. Chopra, V. L. 2001. Plant Breeding: Field Crops. Oxford IBH Pvt. Ltd., New Delhi

## Paper VIII. PLANT ECOLOGY

### Unit I

**Science of Ecology:** Introduction to ecology, evolutionary ecology, ecological models;  
**Population:** Characteristics of population, population size and exponential growth, limits of population growth, population dynamics, life history pattern, fertility rate and age structure, population growth. Competition and coexistence, intra-specific interactions, interspecific interactions, scramble and contest competition model, mutualism, commensalism and allelopathy, prey-predator interactions.

**Vegetation organization:** Concepts of community and continuum, community coefficients, interspecific associations, ordination, species diversity and pattern diversity in community, concept of habitat and ecotone, ecological niche.

### Unit II

**Vegetation development:** Temporal changes (cyclic and non-cyclic), mechanism of ecological succession (relay floristic and initial floristic composition), succession models (facilitation, tolerance and inhibition models), Changes in ecosystem properties during succession, concept of climax

**Ecosystems:** Nature and size of ecosystem, components of an ecosystem (producers, consumers and decomposers), Grazing (grassland) and Detritus food chain in freshwater ecosystems, food webs, Ecological energetic: Solar radiation and energy intakes at the earth's surface, energy flow models, Productivity of various ecosystems of the world and global biogeochemical cycles of carbon and nitrogen. *Ecosystem services.*

### Unit III

**Ecosystem stability:** Concept (resistance and resilience), ecological perturbations (natural and anthropogenic) and their impact on plant and ecosystems, Restoration of degraded ecosystems, ecology of plant invasion, Environment impact assessment, ecosystem restoration



Biomes, Biodiversity: Major biomes of the world and Impact of changing climate on biomes, Biodiversity: Concept & level, role of biodiversity in ecosystem function and stability, assessment (local, national and global), speciation and extinction, Biodiversity act of India and related international conventions, diversity indices, IUCN Categories of threat, Hot spots.

#### Unit IV

Conservation: Conservation (ex-situ and in situ) and management, International Conservational organizations, sustainable development, natural resource management in changing environment, molecular ecology, genetic analysis of single and multiple population, molecular approach to behavioural ecology, conservation genetics.

Energy: Sources, Fossil fuels, Nuclear fuel, Solar Energy, Fuel Cells, Biomass, Hydropower, Wind Power, Geothermal, Tidal & Wave energy, Energy conservation

#### *Suggested Readings*

1. Smith, R.L. 1996. Ecology and Field Biology, Harper Collins, New York.
2. Muller-Dombois, D. and Ellenberg, H., 1974. Aims and Methods of Vegetation Ecology, Wiley, New York.
3. Begon, M. Harper, J.L. and Townsend, C.R. 1996. Ecology, Blackwell Science, Cambridge, U.S.A.
4. Ludwig, J. and Reynolds, J.F. 1988. Statistical Ecology. John Wiley & Sons.
5. Odum, E.P. 1971. Fundamentals of Ecology, Saunders, Philadelphia.
6. Odum, E.P. 1983. Basic Ecology, Saunders, Philadelphia.
7. Barbour, M.G., Burk, J.H. and Pitts, W.D. 1987. Terrestrial Plant Ecology, Benjamin/Cummings Publication Company, California.
8. Kormondy, E.J., 1996. Concepts of ecology. Prentice-Hall of India Pvt. Ltd., New Delhi.
9. Chapman, J.L. and Reiss, M.J. 1988. Ecology, Principles and Applications. Cambridge University Press. Cambridge. U.K.
10. Molan, B. and Billharz, S. 1997. Sustainability Indicators. John Wiley Sons, New York.

Biomes, Biodiversity: Major biomes of the world and Impact of changing climate on biomes. Biodiversity: conservation, life cycle of biodiversity, ecosystem function and quality assessment (local, national and global), speciation and extinction, Biodiversity act of India and related international conventions, diversity indices, IUCN's Categories of threat, Hot spots

#### Unit IV

Conservation: Conservation (ex situ and in situ) and management, International Conservational organizations, sustainable development, natural resource management in changing environment, molecular ecology, genetic analysis of single and multiple population, molecular approach to behavioural ecology, conservation genetics.

Energy: Sources, Fossil fuels, Nuclear fuel, Solar Energy, Fuel Cells, Biomass, Hydropower, Wind Power, Geothermal, Tidal & Wave energy, Energy conservation

#### *Suggested Readings*

1. Smith, R.L. 1996. Ecology and Field Biology, Harper Collins, New York.
2. Muller-Dombois, D. and Ellenberg, H., 1974. Aims and Methods of Vegetation Ecology, Wiley, New York
3. Begon, M., Harper, J.L. and Townsend, C.R. 1996. Ecology, Blackwell Science, Cambridge, U.S.A.
4. Ludwig, J. and Reynolds, J.F. 1988. Statistical Ecology John Wiley & Sons.
5. Odum, E.P. 1971. Fundamentals of Ecology, Saunders, Philadelphia.
6. Odum, E.P. 1983. Basic Ecology, Saunders, Philadelphia.
7. Barbour, M.G., Burk, J.H. and Pitts, W.D. 1987. Terrestrial Plant Ecology, Benjamin/Cummings Publication Company, California
8. Kormondy, E. J., 1996. Concepts of ecology, Prentice Hall of India Pvt. Ltd., New Delhi
9. Chapman, H. and Rees, M.F. 1988. Ecology, Principles and Applications, Cambridge University Press, Cambridge, U.K.
10. Mohan, R. and Rajan, S. 1997. Sustainability Indicators, John Wiley Sons, New York

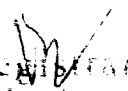
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12. H. G. Wood, A. H. and G. G. (1967). *Ecology*. Cambridge University Press.
13. V. S. Subrahmanyam and V. V. S. S. Sambamurthy (1991). *Ecology*. Eastern Publishing House, Delhi.
14. S. K. Maiti (2004). *Handbook of Methods in Environmental Studies* Vol. 1 & 2. ABD Publisher, Jaipur.
15. J. E. Chapman and M. F. Reiss (1995). *Ecology principles and applications*. Cambridge University Press.
16. C. Faurie, C. Ferrer, P. Medori and J. Devaux (2001). *Ecology Science & Practice*. Oxford and IBH Publishing Co. Pvt. Ltd. New Delhi.
17. G. T. Miller Jr. (2005). *Essentials of Ecology*. III Edition. Thomson, Brooks/Cole.

#### *Suggested Laboratory Exercises*

1. To determine minimum size and number of quadrat required for reliable estimate of biomass in grasslands.
2. To compare protected and unprotected grassland stands using community coefficients (similarity indices).
3. To estimate IVI of the species in a grassland/woodland using quadrat method.
4. To determine gross and net phytoplankton productivity by light and dark bottle method.
5. To determine soil moisture content, porosity and bulk density of soils collected from varying depths at different locations.
6. To determine the Water holding capacity of soils collected from different locations.
7. To determine percent organic carbon and organic matter in the soils of cropland, grassland and forest.
8. To estimate the dissolved oxygen content in eutrophic and oligotrophic water samples by azide modification of Winkler's method.
9. To estimate chlorophyll content in SO<sub>2</sub> fumigated and unfumigated plants leaves.
10. To estimate rate of carbon dioxide evolution from different soils using soda lime or alkali absorption method.
11. To study environmental impact of a given developmental activity using checklist as a tool.

  
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Paper -IX: Plant Resource Utilization and Conservation  
Scheme of Examination Max.Marks : 100

Each paper will have 9 questions, out of which a student has to attempt 5 questions including the question No.1 which will be compulsory. The question No.1 will carry 20 marks and will be of several short objective type of questions such as multiple choice type, true/false answer type, one word type and fill in the blanks type. *a limit of 20 words*

Unit-I  
Plant Biodiversity : Concept, status in India, utilization and concerns.

Sustainable development : Basic Concepts, Origins of agriculture.

World centres of primary diversity of domesticated plants : The Indo-Burmese centre, plant introductions and secondary centres.

Unit-II

Origin, evolution, botany cultivation and uses of : (i) Food forage and fodder crops, (ii) fibre crops, (iii) medicinal and aromatic plants, and (iv) vegetable oil-yielding crops.

Unit-III

Important fire-wood and timber-yielding plants and non-wood forest products (NWFPs) : such as bamboos, rattans, raw materials for paper making, gums, tannins, dyes, resins and fruits.

Green revolution : Benefits and adverse consequences. Innovations for meeting world food demands.

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Plants used as avenue trees for shade, pollution control and aesthetics, Principles of conservation, extinctions, environmental status of plants based on International Union for Conservation of Nature.

#### Unit-IV

Strategies for conservation—*in situ* conservation: International efforts and Indian initiatives, protected areas in India—sanctuaries, national parks, biosphere reserves, wetlands, mangroves and coral reefs, conservation of wild biodiversity.

Strategies for conservation—*ex situ* conservation: Principles and practices, botanical gardens, field gene banks, seed banks, in vitro repositories, cryobanks, general account of the activities of Botanical Survey of India (BSI), National Bureau of Plant Genetic Resources (NBPGR), Indian Council of Agricultural Research (ICAR), Council of Scientific and Industrial Research (CSIR), and the Department of Biotechnology (DBT) for conservation, non-formal conservation efforts.

#### Suggested Readings

- Anonymous 1997. National Gene Bank: Indian Heritage on Plant Genetic Resources (Booklet). National Bureau of Plant Genetic Resources, New Delhi.
- Arora, R.K. and Nayar, E.R. 1984. Wild Relatives of Crop Plants in India. NBPGR Science Monograph No. 7.
- Baker, H.G. 1978. Plants and Civilization (3rd edn.). C.A. Wadsworth, Belmont.
- Bole, P.V. and Vaghani, Y. 1986. Field Guide to Common Indian Trees. Oxford University Press, Mumbai.
- Chandel, K.P.S., Shukla, G. and Sharma, N. 1996. Biodiversity in Medicinal and Aromatic Plants in India: Conservation and Utilization. National Bureau of Plant Genetic Resources, New Delhi.
- Chrispeels, M.J. and Sadava, D. 1977. Plants, Food and People. W.I.I. Freeman and Co., San Francisco.
- Cristi, B.R. (ed.) 1999. CRC Handbook of Plant Sciences and Agriculture. Vol. I. *In-situ* conservation. CRC Press, Boca Raton, Florida, USA.
- Conway, G. 1999. The Doubly Green Revolution: Food for All in the 21st Century. Penguin Books.

9. Conway, G. and Barbier, E. 1990. After the Green Revolution. Earthscan Press, London.
10. Conway, G. and Barbier, E. 1994. Plant, Genes and Agriculture. Jones and Bartlett Publishers, Boston.
11. Council of Scientific and Industrial Research 1986. The Useful Plants of India. Publications and Information Directorate, CSIR, New Delhi.
12. Council of Scientific and Industrial Research (1948-1976). The Wealth of India. A Dictionary of Indian Raw Materials and Industrial Products. New Delhi. Raw Materials I-XII. Revised Vol. I-III (1985-1992) Supplement (2000)
13. Cronquist, A. 1981. An Integrated System of Classification of Flowering Plants. Columbia University Press, New York, USA.
14. Directory of Indian Wetlands, 1993, WWFINDIA, New Delhi and AWB Kuala Lumpur.
15. Falk, D.A., Olwel, M. and Millan C. 1996. Restoring Diversity. Island Press, Columbia, USA.
16. FAO/IBPGR 1989. Technical Guidelines for the Safe Movement of Germplasm. FAO/IBPGR, Rome.
17. Frankel, O.H., Brown, A.H.D. and Burdon, J.J. 1995. The Conservation of Plant Diversity. Cambridge University Press, Cambridge, U.K.
18. Gadgil, M. and Guha, R. 1996. Ecology and Equity: Use and Abuse of Nature in Contemporary India. Penguin, New Delhi.
19. Gaston, K.J. (Ed.) Biodiversity: A Biology of Numbers and Differences. Blackwell Science Ltd., Oxford, U.K.
20. Heywood, V. (Ed.) 1995. Global Biodiversity Assessment. United Nations Environment Programme. Cambridge University Press, Cambridge, U.K.
21. Heywood, V.H. and Wyszelska, P.S. (Eds) 1991. Tropical Botanical Gardens. Their Role in Conservation and Development. Academic Press, San Diego.
22. Kocchar, S.L. 1998. Economic Botany of the Tropics, 2nd edition. Macmillan India Ltd., Delhi.
23. Kothari, A., 1997. Understanding Biodiversity: Life Sustainability and Equity. Orient Logman.
24. Kohli, R., Arya, K.S., Singh, P.H. and Dhillon, H.S. 1994. Tree Directory of Chandigarh. Lovdale Educational, New Delhi.

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- Nair, M.N.B. *et al.* (Eds.) 1988. Sustainable Management of Non-Wood Forest Products. Faculty of Forestry, University Putra Malaysia, 43004 PM Serdang, Selangor, Malaysia.
- Puroda, R.S. and Arora, R.K. 1991. Plant Genetic Resources Conservation and Management. IPGRI (Public Lib) South Asia Office, C/o NBPGR, Pusa Campus, New Delhi.
- Pimentel, D. and Hall, C.W. (Eds.) 1989. Food and Natural Resources. Academic Press, London, New York.
- Pinstrup-Anderson, P. *et al.* 1999. World Food Prospects : Critical Issues for the Early 21st Century. International Food Policy Research Institute, Washington, D.C., USA.
- Plant Wealth of India 1997, Special Issue of Proceedings Indian National Science Academy B-63.
- Plucknett, D.L., Smith, N.J.H., William, J.T. and Murti Annishetty, N. 1987. Gene Banks and World's Food. Princeton University Press, Princeton, New Jersey, USA.
- Rodgers, N.A. and Panwar, M.S. 1988. Planning a Wildlife Protected Areas Network in India. Vol. I The Report. Wildlife Institute of India, Dehradun.
- Sahni, K.C. 2000. The Book of Indian Trees. 2nd edition. Oxford University Press, Mumbai.
- Schery, R.W. 1972. Plants for Man. 2nd ed. Englewood Cliffs, New Jersey. Prentice Hall.
- Sharma, O.P. 1996. Hill's Economic Botany (Late Dr. A.F. Hill, adapted by O.P. Sharma). Tata McGraw Hill Co., Ltd., New Delhi.
- Swaminathan, M.S. and Kocchar, S.L. (Eds.) 1989. Plants and Society. Macmillan Publication Ltd., London.
- Triakur, R.S., Puri, H.S. and Husain, A. 1989. Major Medicinal Plants of India. Central Institute of Medicinal and Aromatic Plants, CSIR, Lucknow.
- Thomas, P. 2000. Trees : Their National History. Cambridge University Press, Cambridge.
- Wanger, H., Hikico, H. and Furnsworth, N. 1989. Economic and Medicinal Plant Research. Vols. 1-3. Academic Press, London.
- Water, K.S. and Gillett, H.J. 1998. IUCN Red List of Threatened Plant. IUCN, the World Conservation Union. IUCN, Gland, Switzerland and Cambridge, U.K.

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**Suggested Laboratory Exercises**

The Practical course is divided into three units : (1) Laboratory work, (2) Field survey, and (3) Scientific visits.

**Laboratory Work**

1. Food Crops: Wheat, rice, maize, chickpea (Bengal gram), potato, tapioca, sweet potato, sugarcane, morphology, anatomy, microchemical tests for stored food materials.
2. Forage/ fodder crops : Study of any five important crops of the locality (for example fodder sorghum, bajra, berseem, clover, guar bean, gram, Ficus sp.)
3. plant fibres :
  - (a) Textile fibres : cotton, jute, linen, sunn hemp, Cannabis
  - (b) Cordage fibres : coir
  - (c) Fibres for stuffing : silk cotton or kapok
 Morphology, anatomy, (microscopic) study of whole fibres using appropriate staining procedures.
4. Medicinal and aromatic plants : Depending on the geographical location college/university select five medicinal and aromatic plants each from a garden/crop field (or from the wild only if they are abundantly available).  
*Papaver somniferum*, *Atropa belladonna*, *Catharanthus roseus*, *Adhatoda ceylanica* (syn *A. yucca*) *Allium sativum*, *Rauwolfia serpentina*, *Withania somnifera*, *Phyllanthus amarus* (*P. fraternus*), *Andrographis paniculata*, *Aloe barbadensis*, *Mezitha arvensis*, *Rosa* sp., *Pogostemon cablin*, *Organum vulgare*, *Valeriana zizanioides*, *Jasminum grandiflorum*, *Cymbopogon* sp., *Pandanus odoratissimus*.  
 Study of live or herbarium specimens or other visual materials, to become familiar with these resources.
7. Vegetable Oils : Mustard, groundnut, soybean, coconut, sunflower, castor, Morphology, microscopic structure of the oil-yielding tissues, tests for oil and iodine number.
8. Gums, resins, tannins, dyes : Perform simple tests for gums and resins. Prepare a water extract of vegetable tannins (*Acacia*, *Terminalia*, mangroves, tea, *Cassia* spp. Myrobalans) and dyes (turmeric, *Bixa orellana*, indigo, *Butea monosperma*, *Lawsonia inermis*) and perform tests to understand their chemical nature.



#### Field Survey

##### Firewood and timber yielding plants and NWF's :

Prepare a short list of 10 most important sources of firewood and timber in your locality. Give their local names, scientific names, and families to which they belong. Mention their properties.

Prepare an inventory of the bamboos and rattans of your area giving their scientific and local names and their various uses with appropriate illustrations.

A survey of a part of the town or city should be carried out by the entire class, in batches. Individual students will select one avenue/road and locate the trees planted on a graph paper. They will identify the trees mention their size, canopy shape, blossoming and fruiting period, and their status (healthy, diseased, infested, mutilated, misused or dying) and report whether or not the conditions in which they are surviving are satisfactory. The individual reports will be combined to prepare a larger map of the area, which can be used for subsequent monitoring either by the next batch of students/teachers/local communities/NGOs or civic authorities. The purpose of exercise in item C above is to make the students aware of the kinds of trees and value in urban ecosystems and ecological services.

#### Scientific Visits\*

Students should be taken to one of the following :

- i. A protected area (biosphere reserve, national park, or a sanctuary)
- ii. A wetland
- iii. A mangrove
- iv. National Bureau of Plant Genetic Resources, New Delhi-110012 or, one of its field stations.
- v. Head Quarters of the Botanical Survey of India or one of its Regional Circles.
- vi. A CSIR Laboratory doing research on plants and their utilization.
- vii. An ICAR Research Institute or a field station dealing with one major crop or crops.
- viii. A recognised botanical garden or a museum (such as those at the Forest Research Institute, Dehradun, National Botanical

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Institute, Lucknow, Tropical Botanical Garden and Research Institute, Trivandram), which has collection of plant products.

Note: The students are expected to prepare a brief illustrated narrative of the field survey and scientific visits. After evaluation, the grades awarded to the students by the teachers should be added to the field assessment of the practical examination.

Paper-X : Biotechnology and Genetic Engineering of Plants and Microbes

Schemes of Examination Max. Marks : 100

Each paper will have 9 questions, out of which a student has to attempt 5 questions including the question No.1 which will be compulsory. The question No.1 will carry 20 marks and will be of several short objective type of questions such as multiple choice type, one line answer type, one word type and fill in the blanks type with

a limit of 20 words Unit-I

Biotechnology : Basic concepts, principles and scope.

Plant Cell and tissue culture : General introduction, history, scope, concept of cellular differentiation, totipotency.

Organogenesis and adventive embryogenesis : Fundamental aspects of morphogenesis : somatic embryogenesis and androgenesis, mechanisms, techniques, and utility.

Unit-II

Somatic hybridization : Protoplast isolation, Fusion and culture, hybrid selection and regeneration, possibilities, achievements and limitations of protoplasts research.

Applications of plant tissue culture : Clonal propagation, artificial seed, production of hybrids and somaclones, production of secondary metabolites/natural products, cryopreservation and germplasm storage.

Recombinant DNA technology : Gene cloning principles and techniques, construction of genomic/cDNA libraries; choice of vectors, DNA synthesis and sequencing, polymerase chain reaction, DNA finger printing.

Unit-III

Genetic engineering of plants : Aims strategies for development of transgenics (with suitable examples), *Agrobacterium* - the natural genetic engineer, T-DNA and transposon mediated gene tagging, chloroplast transformation and its utility, intellectual property

rights, possible ecological risks and ethical concerns.

Microbial genetic manipulation: Bacterial transformation, selection of recombinants and transformants, genetic improvement of industrial microbes and nitrogen fixers, fermentation technology.

#### Cell IV

Genomics and proteomics: Genetic and physical mapping of genes, molecular markers for introgression, cis- and trans-traits, artificial chromosomes, high throughput sequencing, genome projects, bioinformatics, functional genomics, microarrays, protein profiling and its significance.

Bioactive Compounds: Alkaloids, antioxidants, flavonoid, proteins and terpenoids.

#### Suggested Readings

1. Bhojwani, S.S. and Razvi, M.K. 1996. Plant Tissue Culture: Theory and Practice (revised edition). Elsevier Science Publishers, New York, USA.
2. Bhojwani, S.S. 1990. Plant Tissue Culture: Applications and Limitations: Elsevier Science Publishers, New York, USA.
3. Britton, T.A. 1999. Geomet. John Wiley & Sons (Asia) Pvt. Ltd, Singapore.
4. Galley, J.A., Ford-Lewis, B.W. and Newbury, H.J. 1997. Biotechnology and Plant Genetic Resources: Construction and Use. CAB International, Oxford, UK.
5. Christopol, M.J. and Saha, D. 1994. Plants: Genes and Agriculture. Jones & Bartlett Publishers, Boston, USA.
6. Collins, H.A. and Edwards, S. 1991. Plant Cell Culture. Bios Scientific Publishers, Oxford, UK.
7. Geor, A.N. and Nikalou, H. 1995. Microbial Biotechnology. With Erdman & Company, New York, USA.
8. Gustafson, J.E. 2000. Genomes. Kluwer Academic Plenum Publishers, New York, USA.
9. Harry, R.J. 1997. Practical Applications of Plant Molecular Biology. Chapman & Hall, London, UK.
10. Jahn, S.M., Soper, S.K. and Veilleux, R.E. 1996. *in vitro* Haploid Production in Higher Plants, Vol. 1-3. Fundamental Aspects and Methods. Kluwer Academic Publishers, Dordrecht, The Netherlands.

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11. Jölles, O. and Jornvall, H. (eds.) 2000. Proteomics in Functional Genomics. Birkhäuser Verlag, Basel, Switzerland.
12. Kartha, Y.K. 1985. Cryopreservation of Plant Cells and Organs. CRC Press, Boca Raton, Florida, USA.
13. Old, R.W. and Primrose, S.B. 1989. Principles of Gene Manipulation : Blackwell Scientific Publications, Oxford, UK.
14. Primrose, S.B. 1995. Principles of Genome Analysis. Blackwell Science, Ltd., Oxford, UK.
15. Raghavathi, V. 1985. Embryogenesis in Angiosperms: A Developmental and Experimental Study, Cambridge University Press, New York, USA.
16. Raghavan V. 1997. Molecular Biology of Flowering Plants. Cambridge University Press, New York, USA.
17. Shantharam, S. and Montgomery, D.E. 1999. Biotechnology, Biosafety, and Biodiversity. Oxford: IIT Publishing Co. Pvt. Ltd., New Delhi.
18. Vasil, I.K. and Thorpe, T.A. 1994. Plant Cell and Tissue Culture. Kluwer Academic Publishers, The Netherlands.

Suggested Laboratory Exercise:

1. Growth characteristics of *E. coli* using plating and turbidometry methods.
2. Isolation of plasmid from *E. coli* by alkaline lysis method and its quantification spectrophotometrically.
3. Restriction digestion of the plasmid and estimation of the size of various DNA fragments.
4. Cloning of a DNA fragment in a plasmid vector, transformation of the given bacterial population and selection of recombinants.
5. Demonstration of DNA sequencing by amber codon copy method.
6. Isolation of protoplasts from various plant tissues and testing their viability.
7. Effect of physical (e.g. temperature) and chemical (e.g. osmoticum) factors on protoplast yield.
8. Demonstration of protoplast fusion employing PEG.
9. Organogenesis and somatic embryogenesis using appropriate explants and preparation of artificial seeds.
10. Demonstration of androgenesis in *Datura*.
11. Electroporation of protoplasts and by plant of callus formation of the reporter gene.

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12. Co-cultivation of the plant material (e.g. leaf discs) with Agrobacterium and study GUS activity histochemically.

*Suggested Reading (for Laboratory Exercises)*

Butenko, R.O. 2000. Plant Cell Culture. University Press of Pacific.

Gollig, H.A. and Edwards, S. 1998. Plant Cell Culture. Bios Scientific Publishers, Oxford, UK.

Dixon, R.A. (Ed) 1987. Plant Cell Culture: Practical Approach. IRL Press, Oxford.

Olvin, S.B. and Schiperoort, R.A. (Eds) 1994. Plant Molecular Biology Manual. 2nd edition. Kluwer Academic Publishers, Dordrecht, The Netherlands.

George, E.F. 1993. Plant Propagation by Tissue Culture. Part 1. The Technology. 2nd edition. Elsevier Ltd, Edlington, UK.

George, E.F. 1993. Plant Propagation by Tissue Culture. Part 2. In Practice. 2nd edition. Elsevier Ltd, Edlington, UK.

Oliver, B.A. and Thompson, J.B. 1993. Methods in Plant Molecular Biology and Biotechnology. CRC Press, Boca Raton, Florida.

Glover, D.V. and James, B.D. (Eds) 1995. DNA Cloning. A Practical Approach. 2nd Edition. IRL Press, Oxford University Press, Oxford.

Hacken, F.B., Fuchs, J.A. and DeWitt, W. 1988. An Introduction to Recombinant DNA Technology. 2nd Edition. Academic Press, Harcourt Brace Jovanovich, New York.

Hall, R.D. (Ed) 1999. Plant Cell Culture Protocols. Humana Press, Inc, New Jersey, USA.

Shaw, C.H. (Ed) 1983. Plant Molecular Biology: A Practical Approach. IRL Press, Oxford.

Smith, R.L. 2000. Plant Tissue Culture: Techniques and Experiments. Academic Press, New York.

**Paper XI (c) : Advanced Plant Pathology-I**

**Scheme of Examination** **Maximum Marks: 100**

Each paper will have 9 questions, out of which a student has to attempt 5 questions including the question No.1 which will be compulsory. The question No. 1 will carry 20 marks and will be of short answer objective type of question such as multiple choice with a limit of 200 words.

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~~type, one line answer type, one word type, and fill in the blanks type.~~

#### Unit-I

Plant Pathology : History & Scope. Nature, Origin. & Evolution of parasitism. Biotic and abiotic pathogens, Pathogen factors in disease development. Penetration, infection and pathogenesis. Physiological specialisation in phytopathogenic microbes.

#### Unit-II

Host factors in disease development : Inoculum Potential, Phenomena of resistance and susceptibility. Protective and defence mechanisms in plants, Phytoalexins. Breeding for disease resistance plants.

Environmental factors in disease development : Epiphytotics and plant disease forecasting.

#### Unit-III

IPM, Application of biotechnology and information technology in pest management.

Molecular Plant Pathology : Molecular diagnosis, identification of genes and specific molecules in disease development, molecular manipulation of resistance. Non-parasitic diseases and control measures.

#### Unit-IV

Principle of Plant Protection, Physical, Chemical and biological control of plant diseases,

Classification and anatomy of galls : Some insect induced plant galls of Rajasthan, mechanism and physiology of insect galls.

#### Paper-XII (a) : Advanced Plant Pathology-II

#### Scheme of Examination

Max.Marks : 100

Each paper will have 9 questions, out of which a student has to attempt 5 questions including the question No.1 which will be compulsory. The question No. 1 will carry 20 marks and will be of several short objective type of questions such as multiple choice type, one line answer type, one word type and fill in the blanks type.

with a limit of 20 words.

#### Unit-I

Fungal diseases : Symptomatology, disease identification and control of flag smut of wheat, covered smut of barley, blast of paddy, smut Jowar, Red rot of sugarcane, flax rust, early blight of potato.

#### Unit-II

Bacteria : Classification and nomenclature of bacterial plant

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Syllabus  
pathogens. Methods of identification of bacterial pathogens (morphology, physiology, serology and pathogenicity).  
bacterial diseases : Brown rot of potato, blight of rice, soft rot of vegetables, Crown gall disease, angular leaf spot of cotton.

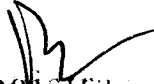
#### Unit-III

Virus, viroid and phytoplasma disease : Symptomatology and transmission of viral diseases; Potato virus X & Y, Tomato ring mosaic, bunchy top of banana; viroids and important viroid diseases. Phytoplasma General account; Sesame phyllody, Spike disease of groundnut.

#### Unit-IV

Nematology : Brief history, classification and identification of plant pathogenic nematodes. Morphology and anatomy of nematodes. Methods used in Nematology.

Control of plant parasitic nematodes. Nematode Disease : Wilya disease of wheat & barley, ear cockle of wheat, root-knot disease.

  
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Paper XI (b): SEED SCIENCE & TECHNOLOGY-I

Unit I

History of seed testing and its importance to agriculture, aims of seed testing, Seed- definition and its types. Sampling of seeds, purity analysis (physical and genetical), seed moisture content, germination test, rapid test of viability and evaluation, seedling evaluation, various methods of seed separation, cleaning, drying and Seed processing plant and its process.

Unit II

Gross architecture of seed structure of angiosperms, identification and structure of seeds of important crop plants with special reference to Rajasthan (wheat, pearl millet, mustard, gram, pea) and Identification of designated objectionable weeds at seed level. Physiology of seed germination; seed and seedling vigour.

Unit III


Principles of seed production, seed production in self and cross pollinated crops; hybrid seed production. Production of foundation and certified seeds; synthetic seed, terminator seed technology, Seed storage methods, principles for safe seed storage, effects of storage, mycotoxins- major groups, detection and detoxification, Deterioration of seeds in storage by micro-organisms, insects and rodents; control of seed deterioration.

Unit IV

Seed certification standards and quarantine regulations. International cooperation, International Seed Testing Association - Rules and recommendations, Certificates, other seed certificates; Indian Seeds Act and recent amendments, National and Regional Seed Corporations of India - their organisation, aims and functions. National and International Co-operation in Seed Pathology. Sanitary and phytosanitary (SPS) agreements of WTO.

**List of suggested Practical exercises:**

1. Structure of seeds of some crop plants (wheat, pearl millet, mustard, gram, and pea).
2. Preparation of inventory of designated objectionable weeds at seed level and identification.
3. Identification of seed coat cracking.
4. Study of physical purity of seed sample.

  
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5. Study of seed germination, seedling abnormality and seedling index.
6. Determination of moisture content of seeds.
7. TZ test for seed viability
8. Assay of enzymes in crop seeds.
9. Preparation of synthetic seeds.
10. Localization of starch, protein, lipids, tannins, phenols and lignin in seed sections.
11. Isolation and identification of storage fungi.
12. Preparation of phytosanitary certificate etc. of seed lot.

*Suggested Readings:*

Agarwal, V.K. and Sinclair, J.B. (1987). Principles of Seed-pathology, II edition CRC Lewis Publishers, Boca Raton, New York, London.

1. Agrawal, R.L. 1980. Seed Technology. Oxford and IBH Publishing Co. Pvt. Ltd. New Delhi.
2. Anonymous (1985, 2014). International rules for seed testing. International Seed Testing Association (ISTA). <http://www.seedtest.org/en/home.html>; <http://www.seedtest.org/en/international-rules-content---1--1083.html>
3. Bewley, J.D. and Black, M. 1983. Physiology and Biochemistry of Seeds in Relation to Germination. Volume I & II. Springer-Verlag, Berlin, Heidelberg, New York.
4. Copeland, L.O. 1976. Principles of Seed Sci. and Technology Minnesota, USA.
5. Khare, D. and Bhale, M.S. (2014). Seed Technology. Scientific Publishers (India), Jodhpur. Revised 2<sup>nd</sup> Ed.
6. Kulkarni, G.N. 2002. Principles of Seed Technology. Kalyani Publishers, New Delhi.
7. Neergaard, P. 1986. Seed- A horse of hunger or a source of life. Revised print of Danish Government Institute of Seed Pathology for Developing Countries. Hellerup, Denmark.
8. Winton, A. L. and Winton, K. B. (1932-1939): The structure and composition of foods. Vol I and II: John Wiley and Sons, Inc., New York.

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Paper XII (b): SEED SCIENCE & TECHNOLOGY -II

Unit I

Introduction and importance of Seed Pathology in modern agriculture. History of Seed Pathology. Various methods for testing seed borne fungi, bacteria and viruses (Dry seed examination, seed washing test, incubation methods, cultural, biochemical, serological, nucleic acid based methods).

Unit II


Mechanism of seed infection and its types, environment influencing seed infection, infected/contaminated part of seed, morphology and anatomy of seeds in relation to invasion, location of inoculum of the pathogen in seed- seed coat and pericarp, endosperm and perisperm and embryo.

Seed-borne diseases of some important crops with particular reference to the state of Rajasthan and India. Typical case of infection by: fungi (wheat- smuts and bunts, Sesame-charcoal rot; bacteria (Brassicas- black rot, cluster bean- bacterial blight); viruses (tomato mosaic virus, pea seed borne mosaic virus,) and nematodes (wheat- ear cockle, rice- white tip).

Unit III

Seed-borne inoculum, inoculum density and assessment of seed borne inoculum in relation to plant infection, epiphytotic due to seed borne inoculum, disease forecast based on infected seed samples, tolerance limits of seed borne pathogens.

Transmission of seed borne disease: Systemic and non- systemic seed transmission, types of disease transmission, mode of establishment and course of disease from seed to seedling and plant, factors affecting seed transmission.

  
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## Unit IV

Management of seed-borne disease, principles of control, seed treatments (physical, chemical and biological), mechanism of action of seed treatments, major seed treatments for important seed borne pathogens and their methods of application.

### List of suggested Practical exercises:

1. Dry seed examination of seed lots.
2. Isolation and identification of seed-borne mycoflora by standard blotter method.
3. Preparation of culture media (PDA and NA).
4. Plating seeds on PDA/NA for identification of seed borne fungi and bacteria.
5. Other methods of plating e.g. deep freezing; 2,4D- blotter method.
6. Water agar test tube seedling symptom test.
7. Study of any seed borne nematode disease.
8. Detection of bacterial and viral pathogens in seeds.
9. LOPAT tests for detection of seed- borne bacteria.
10. Nucleic acid based detection of seed borne pathogens.
11. Histopathology of infected seed samples.
12. Physical control of seed-borne pathogens.
13. Antibiotic/fungicidal assay against seed-borne pathogens
14. Biological control of seed borne pathogens.
15. Field visits: Crop fields, FCI, NSC, Seed testing Labs., quarantine station (e.g. NBPGR) etc.


### Suggested Readings:

1. Agarwal, P. C., Mortensen, C. N. and Mathur, S. B. (1989). Seed-borne diseases and seed health testing of rice. Technical Bull. No.3, Danish government institute of seed Pathology for Developing Countries (DGISP), Copenhagen and CAB International Mycological Institute, (CMI) UK.
2. Agarwal, V.K. 2006. Seed Health. International Book Distributing Company. Charbagh, Lucknow, India.
3. Agarwal, V.K. and Sinclair, J.B. (1987). Principles of Seed-pathology, II edition CRC Lewis Publishers, Boca Raton, New York, London.
4. Agrawal, R.L. 1980. Seed Technology. Oxford and IBH Publishing Co. Pvt. Ltd. New Delhi.
5. Agrios, G.N. 2005. Plant Pathology. Academic Press, London., New York

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6. Anonymous (1985, 2014). International rules for seed testing. International Seed Testing Association (ISTA). <http://www.seedtest.org/en/home.html>; <http://www.seedtest.org/en/international-rules-content---1--1083.html>
7. Clifton, A. 1958. Introduction to the Bacteria. McGraw Hill Book Co., New York.
8. Khare, D. and Bhale, M.S. (2014). Seed Technology. Scientific Publishers (India), Jodhpur. Revised 2<sup>nd</sup> Ed.
9. Mandahar, C.L. 1978. Introduction to plant viruses. S. Chand & Co. Ltd., Delhi.
10. Mathur, S.B. and Cunfer, B.M. 1993. Seed-borne diseases and Seed health Testing of Wheat. Danish Government Institute of Seed Pathology, for Developing Countries. Hellerup, Denmark.
11. Neergaard, P. (1977). Seed Pathology. Vol. I & II. The Mac Millan Press Ltd., London.
12. Rangaswamy, G. & Mahadevan, A. 1999. Diseases of crop plants in India (4th edition). Prentice Hill of India, Pvt. New Delhi.
13. Richardson, M. J. (1990). An annotated list of seed borne diseases 4<sup>th</sup> edn. Proc. Int Seed Test Assoc. Zurich, Switzerland.
14. Schaad, N. W. (1980). Laboratory guide for identification of plant pathogenic bacteria (edt.). Bacteriology Committee of American Phytopathological Society, St. Paul, Minnesota.
15. Schaad, N. W. (1988). Laboratory guide for identification of plant pathogenic bacteria (2<sup>nd</sup> eds.). APS Press (The American Phytopathological Society), St. Paul, Minnesota.
16. Singh, D. and Mathur, S. B. (2004). Histopathology of seed-borne infections. CRC Press, Boca Raton, London, New York, Washington DC. pp 296.
17. Singn, K.G. and Manalo, P.L. 1986. Plant Quarantine and Phytosanitary Barriers in the Asean. Asean Plant Quarantine Centre and Training Institute, Malaysia.

  
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## Paper XI (C): Ecosystem Ecology

### Unit I

**Grassland Ecosystems** - Characteristics of grasslands, stratification, grasslands and grazing, grasslands and drought, grassland and animal life, Grasslands types with special reference to Prairie and Savannah, Indian grasslands.

**Forest Ecosystems** - Stratification of the forest, Forest types -Boreal, Temperate and Tropical forests, Forest animal life

### Unit II

**Freshwater Ecosystems** -Classification of Freshwater Habitats, Lentic: Lakes & Ponds: Temperature and Oxygen stratification, Zonation based on light penetration, Flora and fauna, Productivity classes of lakes, Marshes and Swamps, Bogs, Lotic: Springs, Streams and Rivers.

**Marine and Estuarine Ecosystems** - Characteristics of marine environment: Salinity, Temperature and pressure, Zonation and Stratification, Tides, Estuarine ecosystem: Types of Estuaries, Flora and fauna, Estuarine productivity, Coral reef ecosystem, Mangrove ecosystem

### Unit III

**Urban Ecosystem** -Urban environment and Climatic conditions, additional physical complexes (modified surfaces including parking lots, roofs, and landscaping, buildings, transportation networks, infrastructure and public amenities), flora and fauna (human beings as largest macro consumer), Implications of urbanization: problems of air pollutants, drinking water supply, floods, waste disposal.

**Rural ecosystems:** Rural environment and climate, physical complexes (fields, agricultural implements and machines), Flora and fauna, Problems of discharge of chemical fertilizers, pesticides and drinking water. Management of waste, Principle; Social Forestry.

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## Unit IV

**Desert Ecosystem: Desert:** Definition, classification (hot and cold), physiography, desert features, flora, fauna and water, formation, topography, distribution and characteristics of world deserts; **Thar desert: Sand dunes:** types, origin and morphology of sand dunes; **Vegetation types and plant communities,** biological production, conservation of flora and fauna, wild life, **Succession in vegetation of western Rajasthan and coastal sand dunes,** economic importance of desert plants (general economic plants, medicinal, famine food plants and crops); **Saline Arid zones:** Saline tracts of Rajasthan and plants of saline arid zones (Halophytes), Economic and social considerations in the management of salt affected soils, afforestation in salt affected soils, Importance of halophytes.

### *Suggested Readings*

1. P. L. Jaiswal, A.M. Wadhvani and N.N. Chhabra (Eds.). 1983. Desertification and its Control. ICAR, New Delhi.
2. Smith, R.L. 1996. Ecology and Field Biology, Harper Collins, New York.
3. Subrahmanyam, N.S. and A.V.S.S. Sambamurty 2000. Ecology. Narosa Publishing House, New Delhi.
4. G. M. Masters and W. P. Ela. 2008. Introduction to environmental engineering and sciences. PHI Learning Private Limited, New Delhi.
5. W. P. Cunningham and M. A. Cunningham. 2003. Principles of Environmental Science: Inquiry and Applications. Tata Mcgraw-Hill Publishing Company Limited, New Delhi

### *Suggested Laboratory Exercises*


1. Find out stomatal index of Xerophytes (Nerium, Calotropis, Zizyphus,) growing in your locality.
2. Study of trichomes of xerophytes (Zizyphus, Lantana, Calotropis, Aerea) growing in your locality.
3. Study spread of root system of a perennial species in the soil
4. Study ecological adaptations of halophytes in your nearby area.

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5. Seed Viability by T.T.C. method
6. Dormancy in seeds
7. Soil moisture and temperature at different depths
8. Salinity of soil sample.
9. Study of Canopy and Basal Cover of trees in your study area
10. Estimate primary productivity of a water body by light and dark bottle method
11. Mean leaf area of 2 plant Species growing in your area by graph method
12. Relative humidity by hair hygrometer
13. Light intensity by lux meter

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## Paper XII (C): ENVIRONMENTAL BIOLOGY

### Unit I

**Air Pollution:** Important Primary (CO, CO<sub>2</sub>, Oxides of Sulphur & Nitrogen, H<sub>2</sub>S, Chlorine, Particulates, Odour Producing compounds) & Secondary Air Pollutants (Smog, Acid rain, Primary Photochemical reaction, Formation of ozone and peroxyacetyl nitrate in air), Effects of air pollutants on Buildings & Monuments, plants, man and animals; Biomonitoring, Air pollution control (particulates and gaseous pollutants), Green belt, Ozone depletion, mechanism of depletion, control strategies;


### Unit II

**Water Pollution:** Eutrophication- Process and Control; Oil Pollution, Thermal Pollution, Heavy metal Pollution, Treatment, Disposal & Recycling of Wastewaters, drinking water standards, Minimum National Standards

**Solid & Hazardous waste management & Resource Recovery:** Solid wastes, Types, collection, Shrinking waste streams: 3Rs (Reduction, Recycle & Reuse), composting, energy from waste, demanufacturing; Methods of disposal: Land fill, Open dumps, Exporting waste; Hazardous waste: Definition, disposal and management

### Unit III

**Climate Issues:** Greenhouse gases (CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O, CFCs: sources, trends and role) and consequence of greenhouse effects (CO<sub>2</sub> fertilization, global warming, sea level rise, Biodiversity erosion), Carbon footprints, Carbon sequestration, Applications of GIS and Remote Sensing technology in environmental studies, the future of planet earth.

  
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Policies, Regulations & related issues: Water (Prevention and Control of Pollution) Act 1974; Air (Prevention and Control of Pollution) Act 1981; Environment (Protection) Act 1986, Wild Life Protection) Act 1972, Forest (Conservation) Act 1980, Biodiversity Act 2002.

#### Unit IV


Environmental concerns: Environment auditing, Ecological footprints, Environment Impact Assessment, Bioindicator and biomarkers of environmental health; Environmental economics, Ecopolitics and green policies; Ecolabel, Rain water harvesting, Orans, Indira Gandhi Canal and its ecological implication, water logging & salinity problems- The management alternatives.

#### *Suggested Readings*

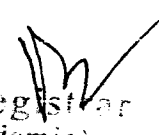
1. Treshow, M. 1985. Air Pollution and Plant Life. Wiley Interscience.
2. Mason, C.F. 1991. Biology of Freshwater Pollution. Longman.
3. Hill, M.K. 1997. Understanding Environmental Pollution. Cambridge University Press.
4. Brij Gopal, P.S.Pathak and K.G. Saxena (Eds.). 1998. Ecology Today: An anthology of Contemporary Ecological Research. International Scientific Publications, New Delhi.
5. P. K. Goel. 1997. Water Pollution: Causes, Effects and Control. New Age international Ltd., Publishers, New Delhi.
6. R.K.Trivedy and P.K.Goel. 1998. An Introduction to Air Pollution. Technoscience Publications, Jaipur
7. I.P.Abrol and V.V. Dhruva Narayana (Editors) 1990. Technologies for Wasteland Development. ICAR, New Delhi.
8. G. M. Masters and W. P. Ela. 2008. Introduction to Environmental Engineering and Sciences. PHI Learning Private Limited, New Delhi.
9. W. P. Cunningham and M. A. Cunningham. 2003. Principles of Environmental Science: Inquiry and Applications. Tata Mcgraw-Hill Publishing Company Limited, New Delhi
10. S.K. Maiti. 2004. Handbook of Methods in Environmental Studies Vol. 1 &2. ABD Publisher, Jaipur.

#### *Suggested Laboratory Exercises*

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1. To estimate pH, EC and Secchi Disc transparency for polluted and unpolluted water bodies.
2. To estimate Chemical Oxygen Demand of polluted water sample.
3. To estimate Biological Oxygen Demand of polluted water sample.
4. To estimate inorganic phosphorus content in water samples collected from polluted and unpolluted water bodies.
5. To estimate Total hardness, calcium and magnesium content in water samples collected from polluted and unpolluted water bodies.
6. To estimate chloride content in water samples collected from polluted and unpolluted water bodies.
7. To estimate Total alkalinity in water samples collected from polluted and unpolluted water bodies.
8. To determine diversity indices (Shannon-Wiener, concentration of dominance, species richness, equitability and  $\beta$ -diversity) for polluted and unpolluted water bodies.
9. Chlorophyll content of plant species growing in polluted (along JLN Marg) and unpolluted habitat (Botany Department).

  
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Paper-XI (d) : Advanced Plant Physiology-I  
Scheme of Examination

Max.Marks : 100

Each paper will have 9 questions, out of which a student has to attempt 5 questions including the question No.1 which will be compulsory. The question No.1 will carry 20 marks and will be of several short objective type of questions such as multiple choice type, one line answer type, one word type and fill in the blanks type. with a limit of 20 words.

Unit-I

Proteins and Enzymes : Techniques of protein purification,

protein sequencing and proteomics, enzyme kinetics, Michaelis-Menten equation and significance of  $K_m$  value, negative and positive cooperativity, enzyme nomenclature and EC number, catalytic mechanisms, acid-base catalysis, covalent catalysis, metal ion catalysis, electrostatic catalysis, catalysis through proximity-orientation effect and catalysis through transition state bonding, lysozyme as model enzyme for catalytic mechanism, regulation of enzyme activity; feedback and allosteric regulation, active sites, cozymes, activators and inhibitors, isoenzymes, ribozymes and abzymes.

Unit-II

Nucleotides : Biosynthesis of ribonucleotides (purines and pyrimidines), formation of deoxyribonucleotides, salvage purines, nucleotide degradation.

Vitamins : Water and fat-soluble vitamins, biochemical function of thiamine, riboflavin, nicotinic acid, pantothenic acid, pyridoxin, folic acid, vitamin B<sub>12</sub>, ascorbic acid, vitamin A and Vitamin E.

Unit-III

Secondary Metabolites :

Coumarins and lignins : Structure and synthesis.

Insecticides : (pyrethrins and rotenoids) distribution, chemistry and function.

Tannins : distribution synthesis and function.

Flavonoids and water-soluble pigments : Synthesis and function.

Hallucinogens : Distribution, chemistry and function.

Unit-IV

Alkaloids : Pyrrole, pyrrolidine, pyridine, polyacetyl piperidine, tropane and indole alkaloids—their distribution, synthesis and function.

Saponins and saponogens : Sterols, steroids, steroidal alkaloids—their distribution, synthesis and function.

Cardiac glycosides : Their distribution, structure and function.

Paper-XII (d) : Advanced Plant Physiology-II

Scheme of Examination

Max.Marks : 100

Each paper will have 9 questions, out of which a student has to attempt 5 questions including the question No.1 which will be com-

pulsory. The question No.1 will carry 20 marks and will be of several short objective type of questions such as multiple choice type, one line answer type, one word type and fill in the blanks type. with a limit of 20 words. Unit-I

**Plant growth regulators :** Natural and synthetic, biochemistry and physiological effects of brassinosteroids, jasmonic acid; salicylic acid, polyamines, morphactins and cyanogenic compounds.

**Signal transduction in plants :** Receptors and G-proteins, phospholipid signalling, role of cyclic nucleotides, calcium-calmodulin cascade, diversity of protein kinases and phosphatases, signal transduction mechanisms with special reference to: Gibberellin induced signal transduction, auxin induced signal transduction and cytokinin induced signal transduction.

#### Unit-II

**Stress physiology :** Plant responses to biotic and abiotic stresses, mechanism of biotic and abiotic stress resistance, plant defense mechanisms against water stress, salinity stress, metal toxicity, freezing and heat stress and oxidative stress.

#### Unit-III

**Photobiology-Photoreceptors, Phytochrome :** history, discovery, physiological properties, interaction between hormones, and phytochrome, role of different phytochromes in plant development and flowering, mechanism of phytochrome signal transduction. Physiology of flowering photo-periodism and vernalisation.

**Circadian rhythms in plants-Nature of oscillator, rhythmic outputs, entrainments (inputs) and adaptive significance.**

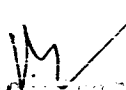
#### Unit-IV

**Tools and Techniques :** Principles and application of spectrophotometry, Principles of chromatography, partition chromatography, thin layer chromatography, ion-exchange chromatography, gas-liquid chromatography, high performance liquid chromatography, gel filtration, electrophoresis, isoelectric focusing, immobilized pH gradient, ultra centrifugation (velocity and density gradient), ELISA and RIA.

**Paper-XI (e) : Advanced Morphology and Morphogenesis-I**  
**Schemes of Examination**

**Max.Marks : 100**

Each paper will have 9 questions, out of which a student has to attempt 5 questions including the question, No.1, which will be com-

  
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compulsory. The question No.1 will carry 20 marks and will be of several short objective type of questions such as multiple choice type, one line answer type, one word type and fill in the blanks type. With a limit of 20 words. Unit-I:

Floral anatomy and its role in explaining the morphology of the Stamen and Carpel, Placentation : Inferior ovary, Taxonomic significance of floral anatomy. Anatomy of the seed and pericarp and their taxonomic significance.

#### Unit-II

Anther-Organizational relationship of anther tissues; Ultrastructure aspect of microsporogenesis : Pollen-sporoderm pattern. Pollen analysis, pollen fertility and sterility, allergy due to pollen. Pollen pistil interaction, cytomorphology of style and stigma, role of pollen ultrastructural studies on pollen tube growth in the pistil, chemotropism, fertilization. Viability, storage and germination of pollen.

#### Unit-III

Embryosac-Basic types and their interrelationships, Ultrastructural aspects of embryosac development. Endosperm—Interrelationship of the major types of endosperms, cytology and role in embryo development, Embryo-Major types, embryogenic laws; comparison of Soueges and Johansen's system; physiological factors controlling growth and differentiation of embryo;

#### Unit-IV

Apomixis—genogenesis, androgenesis, agri-horticultural importance. Embryological features of the following families : Santalaceae, Convolvaceae, Podostemaceae, Cucurbitaceae, Scrophulariaceae, Ranunculaceae, Orobanchaceae, Lentibulariaceae.

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

Schemes of Examination Max Marks : 100

Each paper will have 9 questions, out of which a student has to attempt 5 questions including the question No.1 which will be compulsory. The question No.1 will carry 20 marks and will be of several short objective type of questions such as multiple choice type, one line answer type, one word type and fill in the blanks type. With a limit of 20 words. Unit-I

Development and morphogenesis shoot apex the apical cell,

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meristem, the subcellular and biochemical structure of the meristem. The mechanism of primordium initiation transition to flowering, growth and formation of organs. Experimental work on apical meristem, meristem culture and virus free plant, histochemical studies on apical meristems.

#### Unit-II

The phenomenon of morphogenesis-correlation, polarity, symmetry, differentiation, regeneration.

Morphogenetic factors : Physical, mechanical, chemical and genetic factors. molecular basis of morphogenesis in plants with special reference to work done in Arabidopsis.

#### Unit-III

Somatic embryogenesis-survey of somatic embryogenesis in angiosperms, direct somatic embryogenesis and embryogenesis from callus and protoplasts, cytology, physiology and genesis of somatic embryogenesis nutritional factors, hormonal factors and embryo rescue in wide hybridization.

Micropropagation advances and synthetic seeds.

Cell plating technique and isolation of mutant cell lines, auxotrophic mutants.

Mechanism involved in cell culture mutants.

Suspension culture and growth studies.

#### Unit-IV

Microtechniques for plant cultures. Fixation (FAA and glutaraldehyde) and embedding in paraffin and GMA, equipment and histological procedures. \*Transmission and scanning electron microscopy for plant protoplasts and cultured cells and tissues. Endosperm and ovary culture, control of fertilization, experimental work on embryology of parasitic plants. Role of plant tissue culture in crop improvement.

#### Paper-XI (f) : Biosystematics of Angiosperms-I

Schemes of Examination Max Marks : 100

Each paper will have 9 questions, out of which a student has to attempt 5 questions including the question No.1 which will be compulsory. The question No.1 will carry 20 marks and will be of several short objective type of questions such as multiple choice type, one line answer type, one word type and fill in the blanks type with a limit of 20 words.

### Unit-I

Aims, components and principles of taxonomy, Alpha and Omega taxonomy, documentation, scope, significance and relationship of experimental and orthodox taxonomy, Evolutionary taxonomic classification.

### Unit-II

Botanical gardens and Arboreta, Information from plant geography, Indian plant geographical regions, Role of Herbaria in taxonomy, Taxonomic literature, Taxonomic resource information (Data analysis coding of characters, statistics).

Principles, rules, rank of plant nomenclature, ICBN—Principles and important rules, type method, Principle of priority and its limitation, Name of hybrids and cultivars, Concept of Biocode.

### Unit-III

Biosystematics Procedures : Steps of biosystematic studies, Biosystematic categories—Palynology, Cytology, Embryology, Anatomy and Histochemistry.

### Unit-IV

Numerical taxonomy : Principles, Serum diagnosis Concepts, Phytochemistry Operational taxonomic units (OTU), Data processing and taxonomic studies, Taxometric methods for study of Population variation and similarity—Coding, Cluster analysis, cladistics.

### Paper-XII (I) : Biosystematics of Angiosperms-II

Schemes of Examination Max. Marks : 100

Each paper will have 9 questions, out of which a student has to attempt 5 questions including the question No.1 which will be compulsory. The question No.1 will carry 20 marks and will be of several short objective type of questions such as multiple choice type, one line answer type, one word type and fill in the blanks type. With a limit of 20 words.

### Unit-I

Experimental taxonomy—Scope and Significance, Experimental categories. Relationship in experimental and orthodox taxonomy, Synthetic theory of evolution.

### Unit-II

Concept of species, speciation, species classification, Concept of characters—analytic versus synthetic character, qualitative versus quantitative characters, good and bad characters, Taxonomic charac-

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ter—Character weighing. Characters variation, its role in speciation and isolation.

#### Unit-III

Concept of population, its significance, pattern of phenetic variability, Geographical variability, Transplant experiments. Genotype—environmental interaction, Plasticity, Variation—cause of variation in population, Range of tolerance and phenotypic plasticity, Ecotypes—origin and differentiation, Taxonomic significance of ecotypes.

#### Unit-IV

Experimental taxonomy and hybridization, Role of hybridization in evolution, Stabilization of hybrids and amphidiploidy, introgression and segregation.

Method of analysis of hybrid complex, Introgressive hybridization, Taxonomic treatment of hybrid complex. Breeding barriers, epistasis pleiotropy. Biochemical systematics—method and principles. Systematic markers, chemotaxonomy.

#### *Suggested Readings:*

1. Lawrence, C. I. M. 1951. Taxonomy of Vascular Plants. MacMillan, New York.
2. Davis, P.M. and Heywood, V.H. 1963. Principles of Angiosperm Taxonomy, Oliver and Boyd, London.
3. Heywood, V.H. and Moore, D. H. 1984. Current Concepts in Plant Taxonomy. Academic Press, London.
4. Radford, A.H. 1986. Plant Fundamentals of Plant Systematics. Harper and Row, New York.
5. Stace, C.A. 1989. Plant Taxonomy and Biosystematics, Edward Arnc London.
6. Woodland, D.W. 1991. Contemporary Plant Systematics, Prentice Hall New-Jersey.
7. Nordenstam, B., LT-Gazaly, G. and Kassar, M., 2000. Plant Systematics for 21st Century, Portland Press Ltd., London.
8. Naik, V.N. 1984. Taxonomy of Angiosperms. Tata McGraw Hill, New Delhi.
9. Singh, G. 1999. Plant Systematics : Theory and Practice. Oxford & IBH Pvt. Ltd., New Delhi.
10. Sivarajan, V.V. 1991. [Reprinted 2001] Principles of Plant Taxonomy. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi.

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Paper-XI (g) : Biotechnology-I

Scheme of Examination

Max.Marks : 100

Each paper will have 9 questions, out of which a student has to attempt 5 questions including the question No.1 which will be compulsory. The question No.1 will carry 20 marks and will be of several short objective type of questions such as multiple choice type, one line answer type, one word type and fill in the blanks type.

Unit-I

The concept of totipotency and history of development of plant tissue culture from Haberlandt to the present development of different PTC media and their nutritional components.

Plant tissue culture laboratory—facilities, operation and management, media preparation and handling; Sterile techniques.

Unit-II

Pathways of plant regeneration—proliferation of axillary buds, adventitious shoot bud proliferation, organogenesis and somatic embryogenesis from callus and suspension cultures.

Somatic embryogenesis—Survey of somatic embryogenesis in angiosperms. Zygotic versus somatic embryogenesis in monocots and dicots. Conifer somatic embryogenesis.

Unit-III

Pollen embryogenesis—Discovery of anther culture, survey of anther and pollen culture in dicots and monocots pathways of pollen embryogenesis. cytology and of pollen embryogenesis. stages of pollen development. Haploids for breeding and selection of mutants.

Isolation and culture of protoplasts of grasses review of work done with special reference to rice, wheat and maize.

Propagation of ornamental plants by tissue culture. Application of tissue culture in forestry.

Micropropagation advances and synthetic seeds, use of ELISA methods to certify pathogen free plants.

Unit-IV

Quantification of tissue culture procedures :fresh and dry weight culture density by cell count, packed cell volume mitotic index.

Microtechniques for plant cultures-fixation (FAA and glutaraldehyde) and embedding in paraffin and GMA, equipment and histological procedures. Transmission and scanning electron microscopy for plant protoplasts, cells and tissues.

Staining procedures for chromosome analysis.

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**Paper-XII (g) : Biotechnology-II**

**Scheme of Examination** **Max.Marks : 100**

Each paper will have 9 questions, out of which a student has to attempt 5 questions including the question No.1 which will be compulsory. The question No.1 will carry 20 marks and will be of several short-objective type of questions such as multiple choice type, one line answer type, one word type and fill in the blanks type.

**Unit-I**

**Transgenic plants**—the concept and history of developments of transgenesis in plants.

**Agrobacterium**—mediated transformation.

**Unit-II**

**Direct DNA transfer into intact plants cells**—microprojectile, bombardment and chemical uptake of DNA by plant protoplasts.

**Tools for genetic transformation**—Transformation vectors, promoters, terminators and markers and reporter genes.

**Unit-III**

**Regulation of heterologous gene expression**—factors affecting gene expression, introns, plants transcriptional factors, gene silencing, antisense RNA.

**Transgenic approaches to crop improvement**—protection against biotic (virus, fungi, bacteria, nematode, insect, weed) and abiotic stress (salinity, drought, cold, metals), Nutritional quality improvement-golden rice and other developments. Extension of flower life, pigmentation and fragrance.

**Unit-IV**

**Manufacture of valuable products**—antigens, antibodies, edible vaccines, enzymes, proteins.

**Benefits and risks of producing transgenic plants**—IPR and regulatory requirements, field testing and regulations to release transgenic plants in India.

**Skeleton Paper**

**M.Sc. (Final) Special Paper Adv. Plant Pathology**  
**Practical Examination**

Time : 4 hours

M.M. : 100

Q.No.	Questions	Marks allotted
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|----|--|--|
| 1. | (a) Study the diseased plant material 'A' provided; make histopathological investigations. |  |
|----|--|--|

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	Draw labelled drawing and identify the pathogen giving reasons.	10
(b)	Study and identify the mycoflora from the given material.	5
2.	Give suitable drawings make a suitable preparation so as to study the given material 'C' identify giving reasons.	10
3.	Study the external morphology, histopathology and development stages of given material 'D'. Draw labelled diagrams. Identify the causal organism.	10
4.	Caliberate your microscope with the help of micrometers and measure spores and determine the mean size.	10
5.	From given plant material isolate virus free plantlet through apical meristem culture. Briefly describe the procedure.	8
6.	Stain the given bacterial sample and identify it as gram positive or negative. Write in brief the procedure adopted.	10
7.	Viva-Voce.	10
8.	Spots (Four)	12
9.	Practical record.	15

**Skeleton Paper**

**M.Sc. (Final) Special Paper-Seed  
Technology and Seed Pathology**

**Practical Examination**

Time : 4 hours

M.M. : 100

Q.No.	Questions	Marks allotted
1.	Study the morphological and anatomical features of given seeds.	20
2.	Study the seed-borne mycoflora of given seed sample	25
3.	Determine the location of pathogen in different components of given symptomatic seeds.	10
	or	
	Estimate the spore load in given seed sample.	
4.	Examine the viability of seed lot.	10
	or	
	Study the transmission of pathogen in infected seedling.	

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or  
Examine the seed disorder in given seed lot.  
or  
Examine the seed sample for physical purity

5.	Spots 1-5	10
6.	Viva-Voce	10
7.	Practical Record	15

**Skeleton Paper**

**M.Sc. (Final) Practical Examination  
SPECIAL PAPER : ADVANCE ECOLOGY**

Time: 4 hours

M.M. : 100

1. Determine organic matter content of the given soil sample by Walkely & Black method. 25  
or  
Determine the dissolved O<sub>2</sub> in a given water body by Winkler iodometric method.
2. Prepare the glycerin mount of the given plant materials explaining their anatomical adaptations in relation to habitat. 25  
or  
Study the various types of trichomes and their rolling mechanism to withstand during drought of given plant material.
3. Determine the total hardness of the given water sample. 10
4. Determine pH of the given soil sample by pH meter. 05  
or  
Determine the conductivity of the given soil sample
5. Comment upon the spots (1-5) 10
6. Practical Record 15
7. Viva-Voce 10

**Skeleton Paper**

**M.Sc. (Final) Adv. Plant Physiology  
Practical Examination**

Time : 4 hours

M.M. : 100

Q.No.	Questions	Marks allotted
1.	(a) Perform the physiological exercise given to you and write the object, materials and methods,	

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	theory, observations results and precautions.	25
(b)	Write the details of the principle involved in the given exercise	5
2.	(a) Perform the physiological exercise given to you and write the object, materials and methods, theory, observations, results and precautions.	25
	(b) Perform test(s) for secondary metabolite(s) in the given material.	5
3.	Comment upon Spots 1 & 2	15
4.	Practical Record	10
5.	Viva-Voce	15

**Skeleton Paper**

**M.Sc. (Final) Special Paper Herbarium and Adv. Taxonomy  
Practical Examination**

Time : 4 hours

M.M. : 100

Q.No.	Questions	Marks allotted
1.	Make a study of epidermal system of the material A, B and C from a taxonomic point of view and assign these to their respective types giving reason (any one). or Study the seed-coat anatomy of material A,B and C by means of sections. Give labelled diagrams to bring out the features of systematic significance.	8
2.	Make Palynological study of One of the specimens A, B and C. Draw labelled sketches and give the N.P.C. formula.	10
3.	Study the anatomy of one of the materials A,B and C and mention characters of systematic importance. or Study the floral anatomy by means of serial T.S., of One of the materials A,B and C. Make a labelled sketch.	10
4.	Write a taxonomic description of any one of the twigs. A, B and C on the Flora Indian pattern. Key out these to the level you can.	20

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5.	With the help of suitable preparation make detailed morphological studies of chromosomes in the given material D.	06
6.	Prepare a synonymy on the basis of herbarium sheets studied. Find out the basionym and mention the correct name with reasons.	07
7.	Comment upto the spots 1-6	12
8.	Viva-Voce	10
9.	Record and Sessional Work	17

**Skeleton Paper**

**M.Sc. (Final) Practical Examination**


**Special Paper:- Adv. Morphology of Angiosperms & Pl. Morphogenesis.**

Time : 4 hours

M.M. : 100

1. Cut serial transverse sections of the wax embedded material provided and submit two well prepared slides. Write the procedure followed briefly. 13
2. Study the seed Coat and anatomy of the seed provided. Identify the seed and classify it according to Corner's/Martin's system. 20
3. Make an acetolysed preparation of the pollen grains from the material and describe the pollen morphology and identify the pollen types. 12
4. Dissect out and mount at least two stages of the endosperm/embryo from the material provided, make suitable mounts and labelled diagrams. 10
5. Count the cells in the given suspension culture using haemocytometer to meter. 10  
or  
Plate the cells from the suspension culture using cell plating technique.  
or  
Demonstrate the inoculation of the anthers explant on the culture medium.
6. Comment upon spots 1 to 5 10
7. Viva-Voce 10
8. Practical Record 15

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M.Sc. (Final) Papers VII, VIII, IX & X  
Practical Examination

M.M. : 200

FIRST DAY (4 HRS.)

VII-Plant Development & Reproduction

IX-Plant Resources Utilisation and Conservation

1. (a) Make suitable preparation of the given material. Draw labelled diagram, and study the anatomical features with special reference to its vascular structure. Discuss points of special interest. 16
- (b) With the help of suitable preparation study the floral/seedcoat/epidermal/micro-sporangium wall structure of the material provided. Draw labelled diagram and comment upon its features. 16
2. (a) Identify any two.....materials from the given samples. Give economic importance with special reference to origin, cultivation, part used and processing, if any. 16
- (b) Mark the highest yield producing areas in the map provided to you. 15
3. Spots 1-4 12

M.Sc. (Final) Papers VII, VIII, IX & X  
Practical Examination

Time : 4 hours

M.M. : 200

Second Day (4 Hrs.)

X- Plant Ecology.

XI- Biotechnology and Genetic Engineering of Plants & Microbes.

- 4(a) Calculate the frequency/Density/Species Cover of the plant species in the plot allotted to you by Quadrat method and compare your results with Raunkier frequency diagram. 16
- (b) To investigate the water content/air content/soil particles in given soil sample.  
or  
Investigate the pH/chloride content/oxygen content of water sample given to you. 16
- 5 (a) Perform biotechnological exercise given to you. 16
- (b) Write details for the exercise given to you. 15
6. Spots 1 to 4 12
7. Records/Sessionals/Project/Herbarium 30
7. Viva-Voce. 20

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