

**University of Rajasthan  
Jaipur**

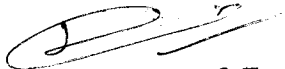

**SYLLABUS**

**M.Sc.**

**BOTANY**

**(ANNUAL SCHEME)**

**2015-2017**

  
Asstt. Registrar (Acad-I)  
University of Rajasthan  
JAIPUR 

UNIVERSITY OF RAJASTHAN, JAIPUR

M.Sc. (BOTANY)

M. Sc. (ANNUAL PATTERN)

2015-2017

Appendix - III

M. Sc. Previous

2015-16

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

2016-17

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)** 2015-16 *WJ*

There will be six papers in theory, each of three hours duration, 100 marks each and two practical's 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)** 2016-17 *WJ*

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

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

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

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**M.Sc. Botany**  
Scheme of Examination

**M.Sc. (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 20 words.

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 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-

pulsory. 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 blanks type.

**Unit-I**

The dynamic cell : Structural organization of the plant cell, specialized plant cell types, chemical foundation, biochemical energetics.

- Cell wall : Structure and functions, biogenesis, growth.
- Plasma membrane : Structures, models and functions, sites for ATPases, ion carriers, channels and pumps, receptors.
- Plasmodesmata : Structure, role in movement of molecules and macromolecules, comparison with gap junctions.

**Unit-II**

Chloroplast : Structure, genome organization, gene expression, RNA editing, nucleochloroplastic interactions.

- Mitochondria : Structure, genome organization, biogenesis.
- Plant vacuole : Tonoplast membrane, ATPase, transporters, as storage organelle.

Nucleus : Structure, nuclear pores, nucleosome organization, DNA structure, A, B and Z forms, replication, damage and repair, transcription, plant promoters and transcription factors, splicing, mRNA transport nucleolus, rRNA biosynthesis.

Restriction enzymes : Cleavage of DNA into specific fragments, construction of a restriction map from the fragments, restriction sites, as genetic markers, RFLP and their use in plant breeding.

**Unit-III**

Ribosomes : Structure, site of protein synthesis, mechanism of translation, initiation, elongation and termination, structure and role of tRNA.

- Protein sorting : Targeting of proteins to organelles.
- Cell shape and motility : The cytoskeleton, organization and role of microtubules and microfilaments, motor movements, implications in flagellar and other movements..

**Unit-IV**

Cell cycle and apoptosis : Control mechanisms, role of cyclins and cyclin-dependent kinases, retinoblastoma and E2F proteins, cytokinesis and cell plate formation, mechanisms of programmed cell death.

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

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

**Suggested Readings:**

1. Lewis, B. 200. 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., Gruissem, 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 Vacuoles : An Introduction. CSIRO Publication Collingwood, Australia.
8. Kleinsmith, L.J. and Kish, 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.

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 EtBr staining.
9. Southern blot analysis using a gene specific probe.
10. Northern blot analysis using a gene specific probe.
11. Immunological techniques : Ouchterlony method, ELISA and western blotting.
12. Fluorescence staining with FDA for cell viability and cell wall staining with calcofluor.
13. Demonstration of SEM and TEM.

Note : Chemicals and kits for conducting some of the above molecular biology experiments are available in India, for example from M/s Bangalore Genei and Centre for Biotechnology (CSTR) Main Road, Delhi.

**Suggested Readings (For Laboratory exercises)**

1. Glick, B.R. and Thompson, J.E. 1993. Methods in Plant Molecular, Biology and Biotechnology. CRC Press, Boca Raton, Florida.
2. Glover, D.M. and Hames, B.D. (Eds.), 1995. DNA Cloning 1: A Practical Approach, Core techniques. 2nd edition. IRL Press at Oxford University Press, Oxford.
3. Gunning, B.E.S. and Steer, M.W. 1996. Plant Cell Biology : Structure and Function; Jones and Bartlett Publishers, Boston, Massachusetts.
4. Hackett, P.B., Fuchs, J.A. and Messing, J.W. 1988. An Introduction to Recombinant DNA Techniques : Basic Experiments in Gene Manipulation. The Benjamin Cummings Publishing Co. Inc., Menlo Park, California.
5. Hall, J.E. and Moore, A.L. 1983. Isolation of Membranes and Organelles from Plant Cells. Academic Press, London, UK.
6. Harris, N. and Oparka, K.J. 1994. Plant Cell Biology : A Practical Approach. IRL Press, at Oxford University Press, Oxford, U.K.
7. Shaw C.H. (Ed.), 1988. Plant Molecular Biology : A Practical

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Approach. IRL Press, Oxford,

Paper-II : Cytology, Genetics and Cytogenetics

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-1

### CYTOLOGY

Chromatin organization : Chromosome structure and packaging of DNA, molecular organization of centromere and telomere, nucleolus and ribosomal RNA genes, euchromatin and heterochromatin, karyotype analysis, banding patterns, karyotype, evolution, specialized types of chromosomes, polytene, lampbrush, B-chromosomes and sex chromosome, molecular basis of chromosome pairing.

Structural and numerical alterations in chromosomes : Origin, meiosis and breeding behaviour of duplication, deficiency, inversion and translocation heterozygotes, Origin, occurrence, production and meiosis of haploids, aneuploids and euploids, origin and production, of autopolyploids, chromosome and chromatid segregation, allopolyploids, types, genome constitution, and analysis, evolution of major crop plants, induction and characterization of trisomics and monosomics.

Unit-II

### GENETICS

Genetics of prokaryotes and eukaryotic organelles : Mapping the bacteriophage genome, phage phenotypes, genetic recombination in phage, genetic transformation, conjugation and transduction in bacteria, genetics of mitochondria and chloroplasts, cytoplasmic male sterility.

Gene Structure and expression : Genetic fine structure, cis-trans test, fine structure analysis of eukaryotes, introns and their significance, RNA splicing, regulation of gene expression in prokaryotes and eukaryotes. Panoply of operon, catabolite repression, attenuation and antitermination.

Genetic recombination and genetic mapping : Recombination

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

Unit-III

### CYTOGENETICS

Mutations : Spontaneous and induced mutations, 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, initiation 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 aneuploids and structural heterozygotes : Effect of aneuploidy on phenotype in plants, transmission of monosomics and trisomics and their use in chromosome mapping in diploid and polyploid species, breeding behaviour and genetics of structural heterozygotes, complex translocation heterozygotes, Translocation tester sets, Robertsonian translocations, B-A translocations.

Unit-IV

Molecular cytogenetics : Nuclear DNA content, C-value paradox, cot curve and its significance, restriction mapping—concept and techniques, multigene families and their evolution, in situ hybridization—concept and techniques, physical mapping of genes of chromosomes, computer assisted chromosome analysis, chromosome interdiffraction and microcloning, flow cytometry and confocal microscopy in karyotype analysis.

Alien gene transfer through chromosome manipulations : Transfer of whole genome, examples from wheat, *A. trichocoma* and *Hordeum*, transfer of individual chromosomes and chromosome segments, methods for detecting alien chromatin, production, characterization 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. Albert B. Bray, D., Lewis, J., Raff, M., Robert, K. and Watson, J.D. 1989., *Molecular Biology of the Cell* (2nd edition), Garland Publishing Inc., New York.
2. Atherly, A.G., Girton, J.R. and McDonald, J.F. 1999. *The Science of Genetics*. Saunders College Publishing, Fort 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., U.S.A.
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 Artlet Publishers, Inc., London.
11. Russel, P.J. 1998. *Genetics* (5th edition). The Benjamin/Cummings Publishing Company Ind., USA.
12. Snustad, D.P. and Simmons, M.J. 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 28SrDNA 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 effect of mono- and tri-somy 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 ratan, Florida.
- 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 several short objective type of questions such as multiple choice type, one word answer type, one word type and fill in the blanks type with a limit of 20 words. Unit-1

**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*, *Hydrodictyon*, *Draparnaldiopsis*, *Cosmarium*, algal blooms, algal biofertilizers : algae as food, feed and use in industry.

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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 Moitra, A. 1996. *Gymnosperms*. New Age International Pvt. Ltd., New Delhi.
- Cole, A.J. 1969. *Numerical Taxonomy*, Academic Press, London,
- Davis, P.H. and Heywood, V.H. 1973, *Principles of Angiosperms Taxonomy*, Robert E. Kreiger Pub. Co., New York.
- Grant, V. 1971. *Plant Speciation*. Columbia University Press, New York.
- Grant, W.F. 1984. *Plant Biosystematics*. Academic Press London.
- Harrison, H.J. 1971. *New Concepts in Flowering Plant Taxonomy*. Hieman Educational Book Ltd., London.
- Heslop-Harrison, J. 1967. *Plant Taxonomy - English Language Book Soc. & Edward Arnold Pub. Ltd. U.K.*
- Heywood, V.H. and Moore, D.M. 1984. *Current Concepts in Plant Taxonomy*. Academic Press, London.
- Jones, A.D. and Wilbins, A.D. 1971. *Variations and Adaptations in Plant Species*. Hiemand & Co. Educational Books Ltd., London.
- Jones, S.B. Jr. and Luchsinger, A.E. 1986. *Plant Systematics* (2nd edition). McGraw-Hill Book Co., New York.
- Nordenstam, B., El Gazaly, G. and Kassas, M. 2000 *Plant Systematics for 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. Gebruder 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) Cappariaceae, (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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## Unit—II

**Mycology :** General characters of fungi, substrate relationship to fungi, cell ultrastructure, unicellular and multicellular organization, cell wall composition, nutrition (saprobic, biotrophic, symbiotic), heterothallism, heterokaryosis, parasexuality, recent trends in classification. Phylogeny of fungi, general account of Mastigomycotina, Zygomycotina, Ascomycotina, Basidiomycotina, deuteromycotina, with special reference to *Pilobolus*, *Chaetomium*, *Morchella*, *Melampsora*, *Polyporus*, *Drechslera* & *Phoma*, fungi in industry medicine and as food, fungal diseases in plants and humans, Mycorrhizae, fungi as biocontrol agents.

## Unit—III

**Bryophyta :** Morphology, structure, reproduction and life history, distribution, classification, general account of Marchantiales, Jungermanniales, Anthocerotales, Sphagnales, Funariales and Polytrichales, with special reference to *Plagiochasma*, *Notothylus* and *Polytrichum*, economic and ecological importance.

## Unit-IV

**Pteridophyta :** Morphology, anatomy and reproduction; classification; evolution of stele, heterospory and origin of seed habit; general account of fossil pteridophyta; introduction to Psilopsida, Lycopsidea, Sphenopsida and Pteropsida; with special reference to *Lycopodium*, *Gleichenia*, *Pteris*, *Isaetes* & *Ophioglossum*.

## Suggested Reading

- Alexopoulos, C.J., Mims, C.W. and Blackwell, M. 1996. Introductory Mycology, John Wiley & Sons Ind.  
Clifton, A. 1958. Introduction to the Bacteria. McGraw-Hill Book Co., New York.  
Kumar, H.D; 1988. Introductory Phycology. Affiliate East-West Press Ltd., New Delhi.  
Mandahar, C.L. 1978. Introduction to Plant Viruses. Chand & Co. Ltd., Delhi.  
Mehrotra, R.S. and Aneja, R.S. 1998. An Introduction to Mycology, New Age Intermediate Press.  
Morris, I.1986. An Introduction to the Algae. Cambridge University Press, U.K.  
Parihar, N.S. 1991. Bryophyta. Central Book Depot, Allahabad.  
Parihar, N.S. 1996. Biology & Morphology of Pteridophytes.

Central Book Depot, Allahabad.

- Puri, P. 1980. Bryophytes. Atma Ram & Sons, Delhi.  
Rangaswamy, G. and Mahadevn, A. 1999. Diseases of Crop Plants in India (4th edition). Prentice Hall of India Pvt. Ltd., New Delhi.  
Round, F.E. 1986. The Biology of Algae. Cambridge University Press, Cambridge.  
Sporne, K.K. 1991. The Morphology of Pteridophytes. B.I. 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*, *Coccytis*, *Pediastrum*, *Hydrodictyon*, *Ulva*, *Pithophora*, *Stigeoclonium*, *Draparnaldiopsis*, *Closterium*, *Cosmarium*, *Chara*, *Stemonitis*, *Peronospora*, *Albugo*, *Mucor*, *Pilobolus*, *Yeast*, *Emericella*, *Chaetomium*, *Pleospora*, *Morchella*, *Melampsora*, *Phallus*, *Polyporus*, *Drechslera*, *Phoma*, *Penicillium*, *Aspergillus*, *Colletotrichum*, *Marchantia*, *Anthoceros*, *Polytrichum*, *Psilotum*, *Lycopodium*, *Selaginella*, *Equisetum*, *Gleichenia*, *Pteris*, *Ophioglossum*, *Isaetes*.
- Symptomology of some diseased specimens: White rust, downy mildew, powdery mildew, rusts, smuts, ergot, groundnut leaf spot, red rot of sugarcane, wilts, paddy blast, citrus canker, bacterial blight of paddy, angular leaf spot of cotton, tobacco mosaic, little leaf of brinjal, sesame phyllody, 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*, *Drechslera*, *Phoma*, *Fusarium*, *Phoma*, *Colletotrichum*, *Graphium*.
- Sterilization methods, preparation of media and stains.
- Paper—IV : Taxonomy and Diversity of Seed Plants
- Mode of Examination Max.Marks : 100
- Each paper will have 9 questions, out of which a student has to

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attempt 5 questions including the question No.1 which will be compulsory. The questions 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

GYMNOSPERMS

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 Cycadales and Cordaitales.

Structure and reproduction in Cycadales, Ginkgoales, Coniferales, Ephedrales, Welwitschiales and Gnetales.

Unit-II

TAXONOMY OF ANGIOSPERMS

Origin of Intrapopulation variation : Population and the environment, ecads and ecotypes, evolution and differentiation of species, various models.

The species concept : Taxonomic hierarchy, species, genus, family and other categories, principles used in assessing relationship, delimitation of taxa and attribution of rank. Salient features of the International Code of Botanical nomenclature.

Taxonomic evidence : Morphology, anatomy, palynology, embryology, cytology, phytochemistry, genome analysis and nucleic acid hybridization.

Unit-III

Taxonomic tools : Herbarium, floras, histological, cytological, phytochemical, serological, biochemical and molecular techniques, computers and GIS.

Systems of angiosperm classification : Phenetic versus phylogenetic systems, cladistics in taxonomy, relative merits and demerits of major systems of classification, relevance of taxonomy to conservation, sustainable utilisation of bio-resources and ecosystem research.

Unit-IV

Concepts of phytogeography : Endemism, hotspots and hottest hotspots, plant explorations, invasions and introductions, local plant diversity and its socio-economic importance.

Phylogeny of Angiosperms : Ancestors of Angiosperms, time and place of origin of Angiosperms. Habit of Angiosperm. Primitive Angiosperms, Interrelationship among the major groups of Angiosperms.

Suggested Readings :

1. Bhatnagar, S.P. and Moitra, A. 1996. Gymnosperms. New Age International Pvt. Ltd., New Delhi.
2. Cole, A.J. 1969. Numerical Taxonomy, Academic Press, London.
3. Davis, P.H. and Heywood, V.H. 1973. Principles of Angiosperm Taxonomy, Robert E. Kreiger Publ. Co., New York.
4. Grant, V. 1971. Plant Speciation. Columbia University Press, New York.
5. Grant, W.E. 1984. Plant Biosystematics. Academic Press, London.
6. Harrison, H.J. 1971. New Concepts in Flowering Plant Taxonomy. Rieman Educational Book Ltd., London.
7. Haslop-Harrison, J. 1967. Plant Taxonomy, English Language Book Soc. & Edward Arnold Pub. Ltd. U.K.
8. Heywood, V.H. and Moore, D.M. 1984. Current Concepts in Plant Taxonomy. Academic Press, London.
9. Jones, A.D. and Wilkins, A.D. 1971. Variations and Adaptations in Plant Species. Himand & Co. Educational Books Ltd. London.
10. Jones, S.B. Jr. and Luchsinger, A.E. 1986. Plant Systematics (2nd edition). McGraw-Hill Book Co., New York.
11. Nordenstam, B., El Gazaly, G. and Kassas, M. 2000. Plant Systematics for 21st Century. Portland Press Ltd., London.
12. Radford, A.H. 1986. Fundamentals of Plant Systematics. Harper & Row Publications, USA.
13. Singh, M. 1978. Embryology of Gymnosperms, Encyclopaedia of Plant Anatomy X. Gebruder Borntraeger, Berlin.
14. Solbrig, O.T. 1970. Principles and Methods of Plant Biosystematics. The MacMillan Co-collier-MacMillan Ltd, London.

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15. Solbrig, O.T. and Solbrig, D.J. 1979. Population Biology and Evolution, Addison-Wesley Publishing Co. Ind USA.
16. Stebbings, G.L. 1974. Flowering Plant-Evolution Above Species Level. Edward Arnold Ltd, London.
17. Stace, C.A. 1989. Plant Taxonomy and Biosystematics (2nd edition) Edward Arnold Ltd., London.
18. Takhtajan, A.L. 1997. Diversity and Classification of Flowering Plants. Columbia University Press, New York.
19. Woodland, D.W. 1991. Contemporary Plant Systematics. Prentice Hall, New Jersey.

**Suggested Laboratory Exercises :**

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 *Gnetum*.
2. Study of important fossil gymnosperms from prepared slides and specimens, Angiosperms.
3. Description of a specimen from representative, locally available families.

**List of Locally Available Families :**

- (1) Ranunculaceae, (2) Capparidaceae, (3) Portulacaceae, (4) Caryophyllaceae, (5) Malvaceae, (6) Tiliaceae, (7) Sterculiaceae, (8) Zygophyllaceae, (9) Rhamnaceae, (10) Sapindaceae, (11) Leguminosae, (12) Combretaceae, (13) Myrtaceae, (14) Cucurbitaceae, (15) Umbelliferae-Apiaceae, (16) Rabiaceae, (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) Libiatae, (30) Nyctaginaceae, (31) Polygonaceae, (32) Chenopodiaceae, (33) Amaranthaceae, (34) Aizoaceae, (35) Molluginaceae, (36) Euphorbiaceae, (37) Commelinaceae, and (38) Cyperaceae.
4. Description of 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.

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

**Paper—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 objective type of questions such as multiple choice

one-line answer type, one-word type and fill in the blanks type with limit of 20 words.

**Unit-I**

**Water relation of plants :** Unique physicochemical properties of water, chemical potential, water potential, apparent free space, movement of water, Soil Plant Atmosphere Continuum (SPAC), diurnal regulation of transpiration, signal transduction in guard cell.

**Membrane Transport :** Passive - non-mediated transport and facilitated diffusion, Passive-mediated transport, ATP-driven active transport, Uniport, Symport, Antiport ion channels.

**Nitrogen acids, Proteins and Enzymes :** Nod factor, root nodule formation and nitrogen fixation, structure of amino acids, stereoisomers. Ampholytic properties, synthesis of amino acids by reductive amination, GS-GOGAT system and transamination.

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

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

**Unit-II**

**Carbohydrates :** Classification, structure and function of monosaccharides, Polysaccharides and glycoproteins including starch, cellulose and pectins.

**Photosynthesis :** Photosynthetic pigments, absorption and transformation of radiant energy, photo-oxidation, four complexes of

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thylakoid membranes : photosystem I, cytochrome b-*f* complex, photosystem II and coupling factors, photolysis of water and O<sub>2</sub> evolution, non-cyclic and cyclic transportation of electrons, water-water cycle, proton gradient and photophosphorylation, Calvin cycle, regulation of RUBISCO activity, control of Calvin cycle, C<sub>4</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 CO<sub>2</sub> concentrating mechanism in micro-organism.

#### Unit-III

**Respiration :** Anaerobic and aerobic respiration, amphibolic nature of TCA cycle, pentose phosphate pathway, glyoxylate pathway, oxidative phosphorylation, gluconeogenesis, high energy compounds : their synthesis and utilisation.

**Fat metabolism :** Synthesis of long chain fatty acids, lipid biosynthesis, and oxidation

**Secondary metabolites :** Biosynthesis and function of secondary metabolites with special reference to tannins, alkaloids and steroids.

#### Unit-IV

**Plant growth regulators :** Auxins - chemical nature, bioassay, physiological effects and mode of action.

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

Cytokinins-chemical nature, bioassay, physiological effects and mode of action.

Abseisic acid - chemical nature, bioassay, physiological effects and mode of action.

**Physiology of flowering :** Photoperiodism and vernalization.

#### Suggested Readings :

1. Buchanan, B.B., Gruissem, W. and Jones, R.L. 2000. Biochemistry and Molecular Biology of Plants, American Society of Plant Physiologists, Maryland, USA.
2. Dennis, D.T., Turpin, D.H., Lefebvre, D.D. and Layzell, D.B. (Eds) 1997. Plant Metabolism (second edition). Longman Essex, England.
3. Galston, A.W. 1989. Life Processes in Plants. Scientific American Library, Springer-Verlag, New York, USA.

4. Hooykaas, P.J.J., Hall M.A. and Libbenga, K.R. (eds) 1999. Biochemistry and Molecular Biology of Plant Hormones, Elsevier, Amsterdam, The Netherlands.
5. Hopkins, W.G. 1995. Introduction to Plant Physiology. John Wiley & Sons, Inc., New York, USA.
- Lodish, H., Berk, A., Zipursky, S.L., Matsudaira P., Baltimore, D. and Darnell, J. 2000. Molecular Cell Biology (fourth edition). W.M. Freeman and Company, New York, USA.
- Moore, T.C. 1989. Biochemistry and Physiology of Plant Hormones. (second edition). Springer-Verlag, New York, USA.
- Nobel, P.S. 1999. Physicochemical and Environmental Plant Physiology (second edition), Academic Press, San Diego, USA.
- Salisbury, F.B. and Ross, C.W. 1992. Plant Physiology (4th edition). Wadsworth Publishing Co., California, USA.
- Singhal, G.S. Renger, G., Sopory, S.K., Irrgang, K.D. and Govindje 1999. Concepts in Photobiology : Photosynthesis and Photomorphogenesis. Narosa Publishing House, New Delhi.
1. Taiz, I., and Zeiger, E. 1998. Plant Physiology (2nd edition). Sinauer Associates, Inc., Publishers, Massachusetts, USA.
2. Thomas, B. and Vince-Prue, D. (1997) Photoperiodism in Plants (second edition). Academic Press, San Diego, USA.
13. Westhoff, P. (1998) Molecular Plant Development from Gene to Plant, Oxford University Press, Oxford, UK.

#### Suggested Laboratory Exercises :

1. Effect of time and enzyme concentration on the rate of reaction of enzyme (e.g. acid phosphatase nitrate reductase).
2. Effect of substrate concentration on activity of any enzyme and determination of its K<sub>m</sub> value.
3. Demonstration of the substrate inducibility of the enzyme nitrate reductase.
4. Extraction of chloroplast pigments from leaves and preparation of the absorption spectrum of chlorophylls and carotenoids.
5. To determine the chlorophyll a, chlorophyll b, ratio in C<sub>3</sub> and C<sub>4</sub> plants.
6. Isolation of intact chloroplasts and estimation of chloroplast proteins by spot protein assay.
7. to demonstrate photophosphorylation in intact chloroplasts, resolve the phosphoproteins by SDS-PAGE and perform autoradiography.

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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 esterases, 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. Tools in Biochemistry. John Willey, New York, USA.
3. Copeland, R.A. 1996. Enzymes : A Practical introduction to Structure, Mechanism and Data Analysis. VCH Publishers, New York.
4. Dennison, C. 1999. A Guide to Protein Isolation. Kluwer Academic Publishers, Dordrecht, The Netherlands.
5. Devi, P. 2000. Principles and Methods of Plant Molecular Biology. Biochemistry and Genetics. Agrobios, Jodhpur, India.
6. Dryer, R.L. and Lata, G.F. 1989. Experimental Biochemistry. Oxford University Press, New York.
7. 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.

- Moore, T.C. 1974. Research Experiences in Plant Physiology : A Laboratory Manual, Springer-Verlag, Berlin.
10. Ninfa, A.J. and Ballou, D.P. 1998 Fundamental Laboratory Approaches for Biochemistry and Biotechnology. Fitzgerald Science Press, Inc. Maryland, USA.
11. Pummer, D.T. 1998. An Introduction to Practical Biochemistry. Tata McGraw-Hill Publishing Co. Ltd, New Delhi.
12. Scott, R.P.W. 1995. Techniques and Practice of Chromatography. Marcel Dekker, Inc. New York.
13. Wilson, K. and Goulding, K.H. (Eds), 1986. A Biologists Guide to Principles and Techniques of Practical Biochemistry. Edward Arnold, London, UK.
14. Wilson, K. and Walker, J. 1994. Practical Biochemistry : Principles and Techniques. 4th edition, Cambridge University Press Cambridge, UK.

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

**Mode 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 or two answer type, one word type and fill in the blanks type. *with a limit of 20 words*

**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: salient 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. Phytoplasmata : 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 biosurfactants.

## 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), crucifer (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 Readings

1. Alexopoulos, C.J., Minis, C.W. and Blackwel, M. 1996. Introductory Mycology. John Wiley & Sons Inc.
2. Agrios, G.N. 1997. Plant Pathology. Academic Press, London.
3. Albajes, R., Gullino, 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. Mandahar, G.I. 1978. Introduction to plant viruses. Chand & Co. Ltd. Delhi.

Mehrotra R.S. Plant Pathology. Tata McGraw Hill.

Rangaswamy, G. & Mahadevan, A. 1999. Diseases of crop plants in India (4th edition) Prentice Hall of India, Pvt. New Delhi.

Horsfall, J.G. & A.L. Dimond. Plant Pathology Vols. 1, 2 & 3. Academic press, New York, London.

Arvedi, P.C. 1998. Nematode Diseases in Plants. CBS Publisher & Distributor, New Delhi.

## Suggested Laboratory Exercises (Microbiology)

Calibration of microscope : determination of dimensions of micro-organisms (suggested model organisms : yeast, lactobacilli, cyanobacteria).

Cultivation media for autotrophic and heterotrophic microorganisms (cleaning of glasswares, mineral media, complex media, solid media, sterilization) (based on topic 3).

Isolation of microorganisms, streaking on agar plates/pour plate method, isolation of clones, preservation (based on topics 2 and 3).

Determination of growth of a microorganism (model organism : *Escherichia coli*, effects of nutrients, e.g. glucose, fructose, sucrose, principle of colorimetry/spectrocolorimeter) (based on topic 3).

Determination of microbial population size (suggested model organism yeast, use of haemocytometer, serial dilution technique, relationship between dilution and cell count, determination of standard error, reliability in cell counts) (based on topic 3).

Preparation of Winogradsky column using pond bottom mud, observations on temporal sequence of appearance of microbes (visual appearance, microscopic observations) (based on topic 7).

Observation on virus infected plants (symptoms) (based on topic 5).

Fermentation by yeast (inverted tube method, use of different substrates, e.g. glucose, fructose, cane sugar, starch) (based on topic 8).

## Plant Pathology :

Diseases as per theory syllabus.

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**Skeleton Paper**

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

Time : 6 Hours

M.M. : 150

Q.No.	Questions	Marks allotted
1.	(a) Perform the given molecular biology exercise.	16
	(b) Perform the given exercise of cell biology/ molecular biology.	15
2.	(a) Perform the given exercise of Genetics/Mitosis/ Meiosis	16
	(b) Perform the given exercise of Cytogenetics/ Polytene chromosome	16
3.	(i) Identify two algae from the given mixture 'A'. Draw labelled diagrams. Comment upon their significant characters and systematic.	8
	(ii) Make a suitable preparation of material 'B' so as show reproductive parts of the fungus.	8
	(iii) Draw well labelled diagrams. Identify the fungus giving reasons.	8
	(iv) Make a suitable preparation of vegetative/ reproductive parts of the material 'C'. Draw labelled sketches. Write features of special interest and identify giving reasons.	8
4.	Identify the spots critically (6x3)	18
5.	Sessional marks	22
6.	Viva-voce.	15

**Skeleton Paper**

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

Time : 6 Hours

M.M. : 150

Q.No.	Questions	Marks allotted
1.	(a) Describe the material in semitechnical language. Assign it to the relevant family with reasons. Draw floral diagram.	9

- (b) Prepare an artificial key of the given plant materials (A, B & C). 6
- (c) Make a suitable preparation of material 'D' (vegetative part only). Draw labelled diagram. Identify it giving reasons. Also give features of 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 6x3	18
Herbarium	5
Sessional Marks	22
Viva voce	15

- Plant Morphology, Developmental Anatomy*  
*M.Sc. Final & Reproductive Biology*
- 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-XI(b) : Seed Science and Technology-I
  - Paper-XI(b) : Seed Science and Technology-II.

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*Ecosystem Ecology*

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

Paper-VII : Plant Development and Reproduction  
 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

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

Seed germination and seedling growth : Metabolism of nucleic acids, proteins and mobilization of food reserves, tropisms, 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, 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 : Determination, phyllotaxy, control of leaf form, differentiation of epidermis (with special reference to stomata and trichomes) and mesophyll.

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

Reproduction : Vegetative options and sexual reproduction,

flower development, genetics of floral organ differentiation, homeotic mutants in *Arabidopsis* and *Antirrhinum* sex determination.

Unit-III

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, breeding systems, commercial considerations, structure of the pistil, pollen-stigma interactions, sporophytic and gametophytic self-incompatibility (cytological, biochemical and molecular aspects), double fertilization, retro fertilization.

Unit-IV

1. Seed development and fruit growth : Endosperm development during early maturation and desiccation stages, embryogenesis, ultrastructure and nuclear cytology, 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.

2. Latent life-dormancy : Importance and types of dormancy, seed dormancy, overcoming seed dormancy, bud dormancy.

3. Senescence and programmed cell death (PCD) : Basic concepts, types of cell death, PCD in the lifecycle of plants, metabolic changes, associated with senescence and its regulation, influence of hormones and environmental factors on senescency.

Suggested Reading

1. Atwill, B.J. Kriedemann, P.H. and Jumbull, C.G.N. (eds), 1999. Plants in Action : Adaption in Nature Performance in Cultivation, MacMillan Education, Sydney, Australia.
2. Bewley, J.D. and Black, M. 1994. Seeds : Physiology of Development and Germination, Plenum Press, New York.
3. Bhojwani, S.S. and Bhatnagar, S.P. 2000. The Embryology of Angiosperms (4th revised and enlarged edition). Vikas Publishing House, New Delhi.

**PAPER VII: PLANT MORPHOLOGY, DEVELOPMENTAL ANATOMY  
& REPRODUCTIVE BIOLOGY**

**Unit I**

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

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

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

**Unit II**

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

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

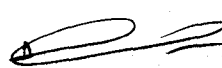
**Seed coat development:** External and internal morphology of seed, seed appendages, ontogeny of seed coat in various families, mature structure, spermoderm patterns.

**Unit III**

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

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

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

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

#### Unit IV

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

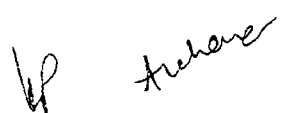
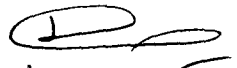
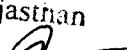
**Polyembryony, apomixis, embryo culture**, dynamics of fruit growth, biochemistry and molecular biology of fruit maturation.

**Latent life - dormancy**: importance and types of dormancy, seed dormancy, overcoming seed dormancy, bud dormancy.

**Senescence and programmed cell death (PCD)** : Basic concepts, types of cell death, PCD in the life cycle of plants. metabolic changes associated with senescence and its regulation, influence of hormones and environmental factors on senescence.

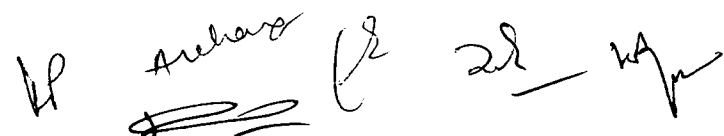
#### *Suggested Readings:*

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

  
  
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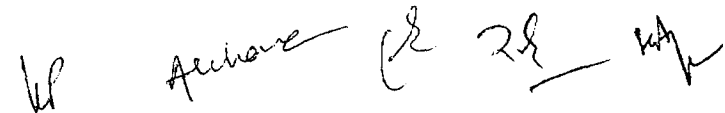
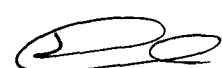
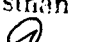
12. Steeves, T.A. and Sussex, I.M., 1989. Patterns in Plant Development (2nd edition). Cambridge University Press, Cambridge.
13. Bhojwani, S.S. and Bhatnagar, S.P. 2000. The Embryology of Angiosperms (4<sup>th</sup> revised and enlarged edition). Vikas Publishing House, New Delhi.
14. Fosker, D.E. 1994. 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.


  
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The American Society of Plant Physiologists, Rockville, Maryland. USA.

### 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*, *Crotalaria*, *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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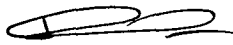
19. Estimating percentage and average pollen tube length in vitro.
20. Study of ovules in cleared preparations, study of monosporic, bisporic and tetrasporic types of embryo sac development through examination of permanent, stained serial sections.
21. Field study of several types of flower with different 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, y. L. 2001. Plant Breeding: Field Crops. Oxford IBH Pvt. Ltd., New Delhi

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## 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 Wily Sons, New York.

11. Heywood, V.H. and Watson, R.T. 1985. Global Biodiversity Assessment. Cambridge University Press.
12. N.S. Subrahmanyam and A.V. S.S. Sambamurty. 2000. Ecology. Narosa Publishing House, Delhi
13. S.K. Maiti. 2004. Handbook of Methods in Environmental Studies Vol. 1 &2. ABD Publisher, Jaipur.
14. J. L. Chapman and M. J. Reiss. 1995. Ecology principles and applications. Cambridge University Press.
15. C. Faurie, C. Ferra, P. Medori and J. Devaux. 2001. Ecology Science & Practice. Oxford and IBH Publishing Co. Pvt. Ltd. New Delhi.
16. 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 Wrinkler'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 EIA method.


  
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4. Burgess, J. 1985. An Introduction to Plant Cell Development. Cambridge University Press, Cambridge.
5. Fagerl, K. and Vander Pijl, L. 1979. The Principles of Pollination Ecology. Pergamon Press, Oxford.
6. Fahn, A. 1982. Plant Anatomy. (3rd edition). Pergamon Press, Oxford.
7. Fosker, D.E. 1994. Plant Anatomy. (3rd edition). Pergamon Press, Oxford.
8. Howell, S.H. 1998. Molecular Genetics of Plant Development. Cambridge University Press, Cambridge.
9. Leins, P., Tueker, S.C. and Endress, P.K. 1988. Aspects of Floral Development. J. Crampar, Germany.
10. Lyndon, L.F. 1990. Plant Development. The Cellular Basis, Unwin Hyman, London.
11. Murphy, T.M. and Thompson, W.E. 1988. Molecular Plant Development. Prentice Hall, New Jersey.
12. Proctor, M. and Yeo, P. 1973. The Pollination of Flowers. William Collins Sons, London.
13. Raghavan, V. 1997. Molecular Embryology of Flowering Plants. Cambridge University Press, Cambridge.
14. Raghavan, V. 1999. Development Biology of Flowering Plants. Springer-Verlag, New York.
15. Raven, P.H., Evert, R.F. and Eichhorn, S. 1992. Biology of Plants (5th edition). Worth, New York.
16. Salisbury, P.B. and Ross, C.W. 1992. Plant Physiology (4th edition). Wadsworth Publishing, Belmont, California.
17. Steeves, T.A. and Sussex, I.M., 1989. Patterns in Plant Development (2nd edition). Cambridge University Press, Cambridge.
18. Sdgely, M. and Griffin, A.R. 1989. Sexual Reproduction to Tree Crops. Academic Press, London.
19. Waisel, Y., Eshel, A. and Kafkaki, U. (eds.). 1996. Plant Roots : The Hidden Half (2nd edition). Marcel Dekker, New York.
20. Shivanna, K.R. and Sawhney, V.K. (eds.) 1997. Pollen Biotechnology for Crop Production and Improvement. Cambridge University Press, Cambridge.
21. Shivanna, K.R. and Rangaswamy, N.S. 1992. Pollen Biology : A Laboratory Manual. Springer-Verlag, Berlin.
22. Shivanna, K.R. and Johri, B.M. 1995. The Angiosperm Pollen

- Structure and Function. Wiley Eastern Ltd., New York.
3. The Plant Cell Special Issue on Reproductive Biology of Plants. Vol. 5(10) 1993. The American Society of Plant Physiologists, Rockville, Maryland, USA.
- Suggested Laboratory/Field Exercises**
1. Effect of gravity, unilateral light and plant growth regulators on the growth of young seedlings.
  2. Role of dark and red light/far-red light on the expansion of cotyledons and epicotylar hook opening in pea.
  3. Study of living shoot apices by dissections using aquatic plants such as *Ceratophyllum* and *Hydrilla*.
  4. Study of cytological zonation in the shoot apical meristem (SAM) in sectioned and double-stained permanent slides of a suitable plant such as *Coleus*, *Kalanchoe*, *tabacco*. Examination of shoot apices in a monocotyledon in both T.S. and L.S. to show the origin and arrangement of leaf primordia.
  5. Study of alternate and distichous, alternate and superposed, opposite and superposed, opposite and decussate leaf arrangement. Examination of rosette plants (*Launus*, *Mollugo*, *Raphanus*, *Hyoscyamus* etc.) and induction of bolting under natural conditions as well as by GA treatment.
  6. Microscopic examination of vertical sections of leaves such as *Cannabis*, *tabacco*, *Nerium*, maize and wheat to understand the internal structure of leaf tissues and trichomes, glands etc. Also study the C<sub>3</sub> and C<sub>4</sub> leaf anatomy of plants.
  7. Study of epidermal peels of leaves such as *Coccinia*, *Gaillardia*, *Tradescantia*, *Notoxys* etc. to study the development and final structure of stomata and prepare stomatal index. Demonstration of the effect of ABA on stomatal closure.
  8. Study of whole roots in monocots and dicots. 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, *Pistia*, *Jussiaea* etc.). Origin of lateral roots. Study of leguminous roots with different types of nodules.
  9. Study of microsporogenesis and gametogenesis in sections of anthers.
  10. Examination of modes of anther dehiscence and collection of

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- pollen grains for microscopic examination (maize, grasses/*Cannabis sativa*, *Crocaloria*, *Tradescantia*, *Brassica*, *Peunia*, *Solanum melongena*, etc.)
11. Tests for pollen viability using stains and in vitro germination. Pollen germination using hanging drop and sitting drop cultures, suspension culture and surface culture.
  12. Estimating percentage and average pollen tube length in vitro.
  13. Role of transcription and translation inhibitors on pollen germination and pollen tube growth.
  14. Pollen storage, pollen-pistil interaction, self-incompatibility, in vitro pollination.
  15. Study of ovules in cleared preparations, study of monosporic, bisporic and tetrasporic types of embryo sac development through examination of permanent, stained serial sections.
  16. Field study of several types of flower with different pollination mechanisms (Wind pollination, thrips pollination, bee/butterfly pollination, bird pollination).
  16. Emasculation, bagging and hand pollination to study pollen germination, seed set and fruit development using self compatible and obligate outcrossing systems. Study of cleistogamous flowers and their adaptations.
  18. Study of nuclear and cellular endosperm through dissections and staining.
  19. Isolation of zygotic globule, heart-shaped, torpedo stage and mature embryos from suitable seeds and polyembryony in citrus, jamun (*Syzygium cumini*) etc. by dissections.
  20. Study of seed dormancy and methods to break dormancy.

**Suggested Reading, (for Laboratory Exercises)**

1. Shivanna, K.R. and Rangaswamy, N.S. 1992. Pollen Biology, Manual, Springer-Verlag, Berlin/Heidelberg (and reference 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**

**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 ~~general~~ 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**  
 Climate, soil and vegetation patterns of the World : Life zones, major biomes and major vegetation and soil types of the world.  
 Vegetation organization : Concepts of community and continuum, analysis of communities (analytical and synthetical characters), community coefficients, interspecific associations, ordination, concept of ecological niche.  
 Vegetation development : Temporal changes (cyclic and non-cyclic), mechanism of ecological succession (relay floristic and initial floristic composition, facilitation, tolerance and inhibition models), changes in ecosystem properties during succession.

**Unit-II**  
 Ecosystem organization : Structure and functions, primary production (methods of measurement, global pattern, controlling factors), energy dynamics (trophic organization, energy flow pathways, ecological efficiencies), litter fall and decomposition (mechanism, substrate quality and Climatic factors), global biogeochemical cycles of C,N,P and S, mineral cycles (pathways, processes, budgets) in terrestrial and aquatic ecosystems.

Biological diversity : Concept and levels, role of biodiversity in ecosystem functions and stability, speciation and extinction, IUCN categories of threat, distribution and global patterns, terrestrial biodiversity hot spot, inventory.

**Unit-III**  
 Air, water and soil pollution : Kinds, sources, quality parameters, effects on plants and ecosystems.  
 Climate change : Greenhouse gases (CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O, CFCs : sources, trends and role), ozone layer and ozone hole, consequence of climate change (CO<sub>2</sub> fertilization, global warming, sea level rise, UV radiation).

**Unit-IV**  
 Ecosystem stability : Concept (resistance and resilience), ecological perturbations (natural and anthropogenic) and their impact on plants and ecosystems, ecology of plant invasion, environmental

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impact assessment, ecosystem restoration.

Ecological management : Concepts, sustainable development, sustainability indicators.

**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.
  11. Treshow, M. 1985. Air Pollution and Plant Life. Wiley Interscience.
  12. Hyewood, V.H. and Watson, R.T. 1985. Global Biodiversity Assessment. Cambridge University Press.
  13. Manson, C.F. 1997. Biology of Freshwater Pollution. Longman
  14. Hill, M.K. 1997. Understanding Environmental Pollution. Cambridge University Press.
  15. Brady, N.C. 1990. The Nature and Properties of Soils, MacMillan.
- Suggested Laboratory Exercises :**
1. To calculate mean, variance, standard deviation, standard error, coefficient of variation and to use t-test for comparing two means related to ecological data.
  2. To prepare ombrothermic Diagram for different sites on the basis of given data set and to comment on climate.
  3. To find out the relationship between two ecological variables

- using correlation and regression analysis.
- To determine minimum size and number of quadrats required for reliable estimate of biomass in grasslands.
  - To find out association between important grassland species using Chi-square test.
  - To compare protected and unprotected grassland stands using community coefficients (similarity-index).
  - To analysis plant communities using Bra-Curtis-ordination method.
  - To determine diversity indices (Shannon-Wiener, concentration of dominance, species richness, equitability and b-diversity) for protected and unprotected grassland stands.
  - To estimate IVI of the species in a woodland using point centred quarter method.
  - To determine gross and net phytoplankton productivity by light and dark bottle method.
  - To determine soil moisture content, porosity and bulk density of soils collected from varying depths at different locations.
  - To determine the water holding capacity of soils collected from different locations.
  - To determine percent organic carbon and organic matter in the soils of cropland, grassland and forest.
  - To estimate the dissolved oxygen content in eutrophic and oligotrophic water samples by azide modification of Wrinkler's method.
  - To estimate chlorophyll content in  $SO_2$  fumigated and unfumigated plants leaves.
  - To estimate rate of carbon dioxide evolution from different soils using soda lime or alkali absorption method.
  - To study environmental impact of a given developmental activity using checklist as an EIA method.
- Suggested Reading (for Laboratory Exercises)**
1. Krebs, C.J. 1989 : Ecological Methodology. Harper and Row, New York, USA.
  2. Ludwig, J.A. and Reynolds, J.F. 1988. Statistical Ecology, Wiley, New York.
  3. Magurran, A.E. 1988. Ecological Diversity and Its Measurement. Chapman & Hall, London.

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4. Phelou, E.G. 1984. The Interpretation of Ecological Data. Wiley, New York.
5. Sakal, R.R. and Rohlf, F.J. 1995. Biometry, W.H. Freeman & Co., San Francisco.
6. Moore, P.W. and Chapman, S.B. 1986. Methods in Plant Ecology. Blackwell Scientific Publications.
7. Misra, R. 1968. Ecology. Work Book. Oxford IBH, New Delhi.
8. APHA-Standard Methods for the Examination of Water and Waste water, American Public Health Association, Washington, DC.
9. Smith, R.L. 1996. Ecology and Field Biology. Harper Collins, New York.
10. Muller-Dombois, D. and Ellenberg, H. 1974. Atlas and Methods of Vegetation Ecology. Wiley, New York.

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, one line answer type, one word type and fill in the blanks type. with a limit of 20 words.

#### Unit-I

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

Sustainable development : Basic Concepts. Origins of agriculture.

World centre 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.

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.
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- 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.L. Freeman and Co., San Francisco.
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- Conway, G. 1999. The Doubly Green Revolution : Food for All in the 21st Century. Penguin Books.

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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 Wylsackn, 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.

- 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.
- Paroda, R.S. and Arora, R.K. 1991. Plant Genetic Resources Conservation and Management. IPGRI (Publication) South Asia Office, C/o NBPGR, Pusa Campus, New Delhi.
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- 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.
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- Rodgers, N.A. and Panwar, M.S. 1988. Planning a Wildlife Protected Area 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.
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- Thomas, P. 2000. Trees: Their National History. Cambridge University Press, Cambridge.
- Wanger, H., Hikiro, H. and Farnsworth, N. 1989. Economic and Medicinal Plant Research. Vols. 1-3. Academic Press, London.
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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**

- Food Crops:** Wheat, rice, maize, chickpea (Bengal gram), potato, tapioca, sweet potato, sugarcane, morphology, anatomy, microchemical tests for stored food materials.
- Forage/fodder crops :** Study of any five important crops of the locality (for example fodder sorghum, bajra, berseem, clove, guar bean, gram, Ficus sp.)
- plant fibres :**
  - Textile fibres : cotton, jute, linen, sunn hemp, Cannabis
  - Cordage fibres : coir
  - Fibres for stuffing : silk cotton or kapok

Morphology, anatomy, (microscopic) study of whole fibres using appropriate staining procedures.
- 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 cylatica (syn A. vasica) Allium sativum, Rauwolfia serpentina, Withania somnifera, Phyllanthus amarus, (P. fraternus), Andrographis P. paniculata, Aloe barbadensis, Mentha arvensis, Rosa sp., Pogostemon cablin, Origanum vulgare, Vetiveria zizanioides, Jasminum grandiflorum, Cymbopogon sp., Pandanus odoratissimus.*  
Study of live or herbarium specimens or other visual materials, to become familiar with these resources.
- Vegetable Oils :** Mustard, groundnut, soybean, coconut, sunflower, castor, Morphology, microscopic structure of the oil-yielding tissues, tests for oil and iodine number.
- 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 NWT'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 values in urban ecosystems and ecological services.

**Scientific Visits\***

Students should be taken to one of the following :

- A protected area (biosphere reserve, national park, or a sanctuary)
- A wetland
- A mangrove
- National Bureau of Plant Genetic Resources, New Delhi-110012 or one of its field stations.
- Head Quarters of the Botanical Survey of India or one of its Regional Circles.
- A CSIR Laboratory doing research on plants and their utilization.
- An ICAR Research Institute or a field station dealing with one major crop or crops.
- 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.

Unit-IV

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

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

Suggested Readings :

1. Bhojwani, S.S. and Razdan, M.K. 1996. Plant Tissue Culture : Theory and Practice (a 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. Brown, T.A. 1999. Geomes. John Wiley & Sons (Asia) Pvt. Ltd. Singapore.
4. Callow, J.A., Ford-Lloyd, B.V. and Newbury, H.J. 1997. Biotechnology and Plant Genetic Resources : Conservation and Use. CAB International, Oxon, UK.
5. Chrispeels, M.J. and Sadava, D.E. 1994. Plants, Genes and Agriculture. Jones & Bartlett Publishers, Boston, USA.
6. Collins, H-A and Edwards, S. 1998. Plant Cell Culture. Bios Scientific Publishers, Oxford, UK.
7. Glazer, A.N. and Nikaido, H. 1995. Microbial Biotechnology. W.H. Freeman & Company, New York, USA.
8. Gustafson, J.P. 2000. Genomes. Kluwer Academic Plenum Publishers New York, USA.
9. Henry, R.J. 1997. Practical Applications of Plant Molecular Biology. Chapman & Hall, London, UK.
10. Jain, S.M., Sopory, S.K. and Veilleux, R.E. 1996. in vitro Haploid Production in Higher Plants, Vols. 1-5. Fundamental Aspects and Methods, Kluwer Academic Publishers, Dordrecht. The Netherlands.

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11. Jolles, O. and Jornvall, H. (eds.) 2000. Proteomics in Functional Genomics. Birkhauser Verlag, Basel, Switzerland.
12. Kartha, K.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. Raghavan, V. 1986. 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, J.F. 1999. Biotechnology, Biosafety and Biodiversity. Oxford & IBH 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 planting and turbidimetric methods.
2. Isolation of plasmid from *E. coli* by alkaline lysis method and its quantitation 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 Sanger's di-deoxy 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 seed.
10. Demonstration of androgenesis in *Datura*.
11. Electroporation of protoplasts and checking of transient expression of the reporter gene.

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

**Suggested Reading (for Laboratory Exercises)**

1. Butenko, R.G. 2000. Plant Cell Culture, University Press of Pacific.
2. Collin, H.A. and Edwards, S. 1998. Plant Cell Culture. Bios Scientific Publishers, Oxford, UK.
3. Dixon, R.A. (Ed.) 1987. Plant Cell Culture : Practical Approach, IRL Press, Oxford.
4. Gelvin, S.B. and Schiperoort, R.A. (eds.) 1994. Plant Molecular Biology Manual. 2nd edition, Kluwer Academic Publishers, Dordrecht, The Netherlands.
5. George, E.F. 1993. Plant Propagation by Tissue Culture. Part 1. The Technology, 2nd edition. Exegetics Ltd., Edington, UK.
6. George, E.F. 1993. Plant Propagation by Tissue Culture. Part 2. In Practices 2nd edition. Exegetics Ltd., Edington, UK.
7. Glick, B.R. and Thompson, J.E. 1993. Methods in Plant Molecular Biology and Biotechnology. CRC Press, Boca Raton, Florida.
8. Glover, D.M. and Hames, B.D. (Eds.) 1995. DNA Cloning 1:A Practical Approach Core Techniques, 2nd edition. PAS, IRL Press at Oxford University Press, Oxford.
9. Hackett, P.B., Fuchs, J.A. and Messing, J.W. 1918. An Introduction to Recombinant DNA Techniques : Basic Experiments in Gene Manipulation. The Benjamin Cummings Publishing Co., Inc. Menlo Park, California.
10. Hall, R.D. (Ed.) 1999. Plant Cell Culture Protocols. Humana Press, Inc. New Jersey, USA.
11. Shaw, C.H. (Ed.) 1988. Plant Molecular Biology : A Practical Approach IRL Press, Oxford.
12. Smith, R.H. 2000. Plant Tissue Culture : Techniques and Experiments. Academic Press, New York.

**Paper-XI (a) : Advanced Plant Pathology-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 short objective type of questions such as multiple-choice with a limit of 20 words.

## 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>:  
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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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Dr. J. K. Singh

Dr. J. K. Singh

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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 (Brassicac- 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, epiphytotics 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.
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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. Singh, 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





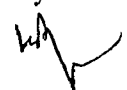

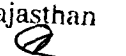
**Freshwater Ecosystems** -Classification of Freshwater Habitats, Lentic: Lakes & Ponds: Temperature and Oxygen stratification, Zonation based on light penetration, Flora and fauna, Productivity classes of lakes, Marshes and Swamps, Bogs, Lotic: Springs, Streams and Rivers.

**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

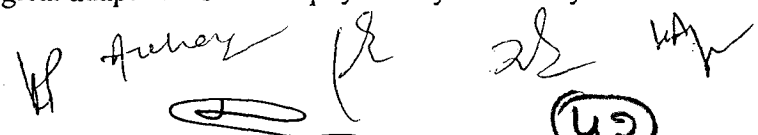
**Desert Ecosystem: Desert:** Definition, classification (hot and cold), physiography, desert features, flora, fauna and water, formation, topography, distribution and characteristics of world deserts; **Thar desert: Sand dunes:** types, origin and morphology of sand dunes; Vegetation types and plant 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;

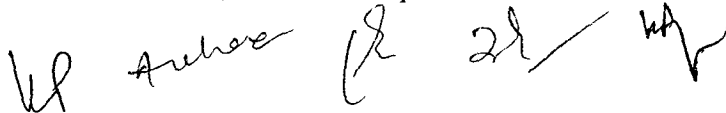


### Unit II

**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*


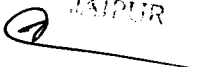
1. Treshow, M. 1985. Air Pollution and Plant Life. Wiley Interscience.
2. Mason, C.F. 1991. Biology of Freshwater Pollution. Longman.
3. Hill, M.K. 1997. Understanding Environmental Pollution. Cambridge University Press.
4. Brij Gopal, P.S.Pathak and K.G. Saxena (Eds.). 1998. Ecology Today: An anthology 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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**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

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 sandal.

**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 : Jalya disease of wheat & barley, ear cockle of wheat, root-knot disease.

**Paper -XI (b) : Seed Science and Technology-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**

**History of seed testing and its importance to agriculture, arms and seed testing, International Seed Testing Association (I.S.T.A.)—rules, prescriptions and recommendations. Sampling of seeds, purity analysis (physical and genetical), seed moisture content, germination and rapid test of viability. seedling evaluation and various methods of seed separation, cleaning and drying.**

**Unit-II**

**Gross architecture of seed structure of angiosperms, identification and structure of seeds of important crop plants and their weeds (with special reference to Rajasthan).**

**Principles of seed production, seed production in self and cross pollinated plants; hybrid seed production.**

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**Unit-III**

Physiology and biochemistry of seed germination, seed and seedling vigour. Seed dormancy and longevity. Seed storage methods, principles for safe seed storage, effects of storage, mycotoxins, Deterioration of seeds in storage by micro-organisms, insects and rodents; control of seed deterioration.

**Unit-IV**

Seed certification standards and quarantine regulations. International cooperations, International Seed Testing, Association—Certificates, other seed certificates Indian Seed Act and National and Regional Seed Corporation of India—their organisation, aims and functions.

Practical work will be based on the theory syllabus.

**Paper-XII(b) : Seed Science And Technology-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**

Introduction and importance of seed pathology in modern agriculture. History of seed pathology. Seed-borne inoculum. Kinds and various methods for testing seed borne fungi, bacteria and viruses. Avenues of seed infection, environment influencing seed infection, infected/contaminated part of seed, morphology and anatomy of seeds in relation to invasion and location of inoculum of the pathogen in seed.

**Unit-II**

Seed-borne diseases of some important crops with particular reference to the state of Rajasthan and India. Typical case of infection by fungi, bacteria, viruses and nematodes; seed storage fungi and the mode of seed deterioration caused by them.

**Unit-III**

Transmission of disease : types of disease transmission, mode of establishment and course of disease from seed to plant. Inoculum density and assessment of seed-borne inoculum in relation to plant infection, epiphytotics due to seed-borne inoculum, disease forecast

based on infected seed samples : Tolerance limits of seed pathogens.

**Unit-IV**

Control of seed borne—disease, principles of control, seed treatments, physical and chemical mechanism of action of seed treatment, major seed treatment for important seed pathogens with particular reference to crops grown in Rajasthan. National and International Co-operation in Seed Pathology.

Practical work will be based on the theory syllabus.

**Paper-XI (c) : Environmental Biology-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**

**ECOSYSTEM** : Structure and ecological processes in the Grassland, Forest, Freshwater and Marine ecosystems, Urban and Rural ecosystems.

**Unit-II**

Remediation of soil, water (municipal and industrial wastewater) and air pollution, solid wastes and their management, Ecolevel, Environment auditing, Ganga action plant, Water (Prevention and Control of Pollution) Act 1974, Air (Prevention and Control of Pollution) Act 1981, Environment (Protection) Act 1986.

**Unit-III**

**Natural Resource Management** : Water, Soil & Energy, Wild Life, Resources; Challenges and priorities in conservation, poaching and killing of wild life. Wild Life (Protection) Act 1972.3 Rs (Reduction, Recycle & Reuse) Principle; Social Forestry; Role of tribals in conservation; Forest (Conservation) Act 1980.

**Unit-IV**

Environment education and awareness; Environment ethics : Issues in perspective and importance; Environment economics : Issues in perspective global/economy; Ecopolitics and green policies; Ecofeminism.

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**Paper-XII (c) : Arid Zone Ecology-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**

Desert, their formation, topography distribution and characteristics of world deserts. Hot and cold deserts with reference to India.

**Unit-II**

The saline tracts and their vegetation (Halphytes) with special reference to Rajasthan, Mangrove vegetation.

Rajasthan-Geology, Physiography, climate soil and water problems in Rajasthan particularly underground water resources and its change.

**Unit-III**

Vegetation of Rajasthan desert and plant communities.

Problem and Management of Sand dunes and desert.

Sand dunes classification, stabilization and management of sand dunes.

**Unit-IV**

Wind break and shelter belt, afforestation and desert control measures. Indira Gandhi Canal and its ecological implication, dry land farming.

Desert as an ecosystem, biological implication, dry land farming.

Desert as an ecosystem, biological production with particular reference to conservation of flora and fauna.

**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 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, coenzymes, 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

**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, polyacetylsanguinolone, tropane and indole alkaloids—their distribution, synthesis and function.

**Saponins and saponinogens** : 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-

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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-

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

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 anaysis, 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 inter-relationships**, Ultrastructural aspects of embryosac development. Endosperm—Inter-relationship 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 (f) : 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. H. 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 Arne 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.

#### 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.



**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
1.	(a) Study the diseased plant material 'A' provided; make histopathological investigations.	

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. Calibrate 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

- 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.
- 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.
- Determine the total hardness of the given water sample. 10
- Determine pH of the given soil sample by pH meter. 05  
or  
Determine the conductivity of the given soil sample
- Comment upon the spots (1-5) 10
- Practical Record 15
- 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,	

	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.  
or  
Plate the cells from the suspension culture using cell plating technique.  
or  
Demonstrate the inoculation of the anthers explant on the culture medium. 10
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. Sports 1 to 4 12
7. Records/Sessionals/Project/Herbarium 30
7. Viva-Voce. 20

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**UNIVERSITY OF RAJASTHAN  
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RULES FOR THE AWARD OF  
GRACE MARKS**

**A. UNDER GRADUATE/POST GRADUATE (MAIN/SUPPLEMENTARY) EXAMINATIONS UNDER THE FACULTIES OF ARTS, FINE ARTS, SCIENCE, COMMERCE, SOCIAL SCIENCES, EDUCATION, MANAGEMENT, HOMOEOPATHY, LAW, AYURVEDA AND ENGINEERING & TECHNOLOGY.**

Grace marks to the extent of 1% of the aggregate marks prescribed for an examination will be awarded to a candidate failing in not more than 25% of the total number of theory papers, practicals, sessionals, dissertation, viva-voce and the aggregate, as the case may be, in which minimum pass marks have been prescribed; provided the candidate passes the examination by the award of such Grace Marks. For the purpose of determining the number of 25% of the papers, only such theory papers, practicals, dissertation, viva-voce etc. would be considered, of which, the examination is conducted by the University.

N.B. : If 1% of the aggregate marks or 25% of the papers works out in fraction, the same will be raised to the next whole number. For example, if the aggregate marks prescribed for the examination are 450, grace marks to the extent of 5 will be awarded to the candidate, similarly, if 25% of the total papers is 3.2, the same will be raised to 4 papers in which grace marks can be given.

**B. DIPLOMA IN PHARMACY, BACHELOR OF PHARMACY, B.Sc. (NURSING) AND B.D.S. EXAMINATIONS**

1. A student who obtains the required minimum pass marks in the total aggregate but fails to obtain the minimum pass marks in (i) two subjects, (ii) in one subject and in one practical or (iii) in two practicals, as the case may be, will be given grace marks according to the following scale, provided the candidate passes the examination by the award of such grace marks.

For 1 to 6 marks above the min. aggregate	: 2 grace marks
For 7 to 12 marks above the min. aggregate	: 3 grace marks
For 14 to 18 marks above the min. aggregate	: 4 grace marks
For 19 and above the min. aggregate	: 5 grace marks

- (i) The theoretical and practical tests (wherever held) in a subject will count as 2 subjects.
- (ii) In case it is necessary to secure minimum pass marks in one part of a subject the above rule will be applicable as follows.

"If a candidate fails in the compulsory part of the subject as well as in the whole subject, he will be deemed to have passed in the subject if the greater of the two deficiencies or where the two deficiencies are equal, one of them is covered by the grace marks to which he is entitled under the rules.

2. No grace marks would be awarded to a candidate who appears in part/supplementary examination.

**C. M.B.B.S. AND B.A.S.L.P. (BACHELOR OF AUDIOLOGY, SPEECH AND LANGUAGE PATHOLOGY) EXAMINATIONS**

1. The grace marks upto a maximum of 5 marks will be awarded to a student who has failed only in one subject (Theory and/or practical) but has passed in all other subject.
2. No grace marks would be awarded to a candidate who appears in part/supplementary examination.

**General**

1. A candidate who passes in a paper/practical or the aggregate by the award of grace marks will be deemed to have obtained the necessary minimum for a pass in that paper/practical or in the

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aggregate and shown in the marks sheet to have passed by grace. Grace marks will not be added to the marks obtained by a candidate from the examiners nor will the marks obtained by the candidate be subject to any deduction due to award of grace marks in any other paper/practical or aggregate.

2. If a candidate passes the examination but misses First or Second Division by one mark, his aggregate will be raised by one mark so as to entitle him for the first or second division, as the case may be. This one mark will be added to the paper in which he gets the least marks and also in the aggregate by showing +1 in the tabulation register below the marks actually obtained by the candidate. The marks entered in the marks-sheet will be inclusive of one grace mark and it will not be shown separately.
3. Non-appearance of a candidate in any paper will make him ineligible for grace marks. The place of a passed candidate in the examination list will, however, be determined by the aggregate marks he secures from the examiners, and he will not, by the award of grace marks, become entitled to a higher division.
4. Distinction won in any subject at the examination is not to be forfeited on the score that a candidate has secured grace marks to pass the examination.

**Note:** The grace marks will be awarded only if the candidate appears in all the registered papers prescribed for the examination.

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