

MAHARSHI DAYANAND SARASWATI UNIVERSITY, AJMER



पाठ्यक्रम SYLLABUS

SCHEME OF EXAMINATION AND COURSES OF STUDY

FACULTY OF SCIENCE

M.Sc. Botany (Previous) & (Final)

2009-10 से प्रभावी(w.e.f.)

सत्र 2013-14

महर्षि दयानन्द सरस्वती विश्वविद्यालय, अजमेर

SCHEME OF EXAMINATION

NOTICE

1. Change in Statutes/Ordinances/Rules/Regulations/ Syllabus and Books may, from time to time, be made by amendment or remaking, and a candidate shall, except in so far as the University determines otherwise comply with any change that applies to years he has not completed at the time of change. **The decision taken by the Academic Council shall be final.**

सूचना

1. समय-समय पर संशोधन या पुनः निर्माण कर परिनियमों / अध्यादेशों / नियमों / विनियमों / पाठ्यक्रमों व पुस्तकों में परिवर्तन किया जा सकता है, तथा किसी भी परिवर्तन को छात्र को मानना होगा बशर्ते कि विश्वविद्यालय ने अन्यथा प्रकार से उनको छूट न दी हो और छात्र ने उस परिवर्तन के पूर्व वर्ष पाठ्यक्रम को पूरा न किया हो। **विद्या परिषद द्वारा लिये गये निर्णय अन्तिम होंगे।**

M. SC. BOTANY ANNUAL PATTERN (PREVIOUS)

I year (Previous)	Maximum Marks	Theory
Paper I	Cytology, Genetics and Cytogenetics	100 Marks
Paper II	Biology and Diversity of Lower plants: Cryptogams	100 Marks
Paper III	Taxonomy and Diversity of Seed Plants	100 Marks
Paper IV	Plant Physiology and Metabolism	100 Marks
Total Theory		400 Marks
Combined Practicals for 4 papers		200 Marks
Exercises based on Experimental work		150 Marks
Seminar		20 Marks
Record		15 Marks
Viva-voce		15 Marks
GRAND TOTAL OF THEORY & PRACTICALS		400+200=600 Marks

M.SC. BOTANY ANNUAL PATTERN M.SC. (FINAL)

Paper V	Plant Development and Reproduction	100 Marks
Paper VI	Plant Ecology and Economic Botany	100 Marks
Paper VII	Biotechnology & Genetic Engineering of Plants & Microbes	100 Marks
Paper VIII	Elective papers Any one of the following three papers: (1) Advanced Plant Pathology or (2) Advanced Plant Physiology or (3) Advanced Plant Ecology	100 Marks
Total Theory		400 Marks
Combined Practical's based on 4 papers		200 Marks
Exercises based on Experimental work		150 Marks
Seminar		15 Marks
Record		15 Marks
Project Work based upon field studies (One Local and One Out side state is compulsory)		10 Marks
Viva-voce		10 Marks
Grand Total of Theory & Practical's		400+200= 600 Marks
GRAND TOTAL M.Sc. Previous & M.Sc. Final year		600+600=1200 Marks

NOTE ON PRACTICAL EXAMINATION SCHEME**(M. SC. BOTANY)**

- I. Combined Practical examination shall be of 10 hours duration in two days time period of 5 hours each day for M.Sc. Previous and Final separately.
- II. Regarding seminars assessment, each student shall orally present 2 seminars of 30 minutes duration each per session in the presence of Head of the Department or Faculty members appointed by him and also submit a write up for each seminar. The seminar evaluation record and project work record be placed by the H.O.D. before the external and internal practical examiners for the purpose of final evaluation by them at the time of practical examination.

M.SC. (PRE.) BOTANY**PAPER I CYTOLOGY, GENETICS AND CYTOGENETICS**

Duration: 3hrs.

Max. Marks: 100

Note :- Each theory paper is divided into three independent units. The question paper is divided into three parts Part -A, Part -B and Part -C. Part A (20 marks) is compulsory and contains 10 questions (20 words each) at least three questions from each unit, each question is of two mark. Part -B (20 marks) is compulsory and contains four questions at least one from each unit. Candidate is required to attempt all four questions. Each question is of five marks (50 words). Part -C (60 marks) contains six questions two from each unit. Candidate is required to attempt three questions one from each Unit. Each question is of twenty marks (400 words).

Unit I

Cell organelles: Ultra structure and functions of Mitochondria, Plastid, Golgi body, Vacuole, Centrosome, Microbodies and Ribosome.

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

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 chromosomes; molecular basis of chromosome pairing.

Structural and numerical alterations in chromosomes: Origin, meiosis and breeding behavior 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, type, genome constitution and analysis; evolution of major crop plants; induction and characterization of trisomics and monosomics.

Unit II

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.

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.

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

Unit III

Cytogenetics of aneuploids and structural heterozygotes: Effect of aneuploidy on phenotype in plants; transmission of monosomics and trisomics and their use in chromosome mapping of diploid and polyploid species; breeding behavior and genetics of structural heterozygotes; complex translocation heterozygotes; translocation tester sets; Robertsonian translocations; B-A translocations.

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 on chromosomes; computer assisted chromosome analysis; chromosome micro-dissection and microcloning; flow cytometry and confocal microscopy in karyotype analysis.

Alien gene transfer through chromosome manipulations: Transfer of whole genome, examples from wheat, *Arachis* and *Brassica* 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.

Suggested readings:

- Lewin, B. 2000. *Genes VII*. Oxford University Press. New York.
- Alberts, B., Bray D., Lewis, J., Raff, M., Roberts, K., and Watson, J.D. 1999. *Molecular Biology of the Cell*. Garland Publishing, Inc., New York.
- Wolfe, S.L. 1993. *Molecular and Cellular Biology*. Wadsworth Publishing Co., California, USA.
- Rost 1 et al. 1998. *Plant Biology*. Wadsworth Publishing Co., California, USA
- Krishnamurthy, K.V. 2000. *Methods in cell wall Cytochemistry*. CRC Press, Boca Raton, florida.
- Buchanan, B.B., Gruissem, W. and Jones, R.L. 2000. *Biochemistry and Molecular Biology of Plants: American Society of Plant Physiologists*, Maryland, USA.
- De, D.N. 2000. *Plant Cell Vacuoles: An Introduction*. CSIRO Publication, Collingwood, Australia.
- Kleinsmith, L.J. and Kish, V.M. 1995. *Principles of Cell and Molecular Biology* (2nd edition). Harper Collins College Publishers, New York, USA.
- Lodish, H., Berk, A., Zipursky, S.I., 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 chloroplasts and SDS-PAGE proteins to demarcate the two subject of Rubisco.
2. Isolation of plant DNA and its quantitation by a spectrophotometric method.
3. Isolation of DNA and preparation of 'cot' curve.
4. Restriction digestion of plant DNA, its separation by agarose gel electrophoresis and visualization by ethidium bromide staining.
5. Isolation of RNA and quantitation by a spectrophotometric method.
6. Separation of plant RNA by agarose gel electrophoresis and visualization by EtBr staining.
7. Immunological techniques: Ouchterlony method, ELISA and western blotting.
8. Demonstration of SEM and TEM.

Suggested Readings

- Alberts, B., Bray, D., Lewis, J., Raff, M., Roberts, K., and Watson, J.D. 1989. *Molecular Biology of the Cell* (2nd edition). Garland Publishing Inc., New York.
- Atherly, A.G., Girtion, J.R. and McDonald, J.F. 1999. *The Science of Genetics*. Saunders College Publishing, Fort Worth, USA.
- Burnham, C.R. 1962. *Discussions in Cytogenetics*. Burgess Publishing Co.,
- Busch, H. and Rothblum, L. 1982. Volume X. *The Cell Nucleus rDNA Part A*. Academic Press.
- Hartl, D.L. and Jones, E.W. 1998. *Genetics: Principles and Analysis* (4th edition). Jones & Bartlett Publishers, Massachusetts, USA
- Khush, G.S. 1973. *Cytogenetics of Aneuploids*. Academic Press, New York, London.
- Karp, G. 1999. *Cells and Molecular Biology: Concepts and Experiments*. John Wiley & Sons, Inc., USA
- Lewin, R. 1997. *Human Genetics; Concepts and Applications* (2nd edition). WCB McGraw Hill, USA
- Ma;acomski, G.M. and Freifelder, D. 1998. *Essentials of molecular Biology* (3rd edition). Jones and Bartlet Publishers, Inc., London.
- Russel, P.J. 1998. *genetics* (5th edition). The Benjamin/Cummings Publishing Company Inc., USA
- 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 and Q-banding.
2. Orcein and Feulgen staining of the salivary gland chromosomes of *Chironomas* and *Drosophila*.
3. Characteristics and behavior of B chromosomes using maize or any other appropriate material.
4. Working out the effect of mono- and tri-somy on plant phenotype, fertility and meiotic behavior.
5. Induction of polyploidy using colchicine; different methods of the application of colchicine.
6. Effect of induced and spontaneous polyploidy on plant phenotype, meiosis, pollen and seed fertility and fruit set.
7. Effect of translocation heterozygosity on plant phenotype, chromosome pairing and chromosome disjunction. Pollen and seed fertility.
8. Meiosis of complex translocation heterozygotes.
9. Isolation of chlorophyll mutants following irradiation and treatment with chemical mutagens.
10. Estimation of nuclear DNA content through microdensitometry and flow cytometry.

PAPER II: BIOLOGY AND DIVERSITY OF LOWER PLANTS: CRYPTOGAMS

Duration: 3hrs.

Max. Marks : 100

Note :- Each theory paper is divided into three independent units. The question paper is divided into three parts Part -A, Part -B and Part -C. Part A (20 marks) is compulsory and contains 10 questions (20 words each) at least three questions from each unit, each question is of two mark. Part -B (20 marks) is compulsory and contains four questions at least one from each unit. Candidate is required to attempt all four questions. Each question is of five marks (50 words). Part -C (60 marks) contains six questions two from each unit. Candidate is required to attempt three questions one from each Unit. Each question is of twenty marks (400 words).

Unit I

Microbiology

- a. Archaeobacteria and eubacteria: General account; ultra-structure, nutrition and reproduction; biology and economic importance; cyanobacteria-salient features and biological importance.
- b. Viruses: Characteristics and ultra-structure of virions; isolation and purification of viruses; chemical nature, replication, transmission of viruses; economic importance.
- c. Phytoplasma: General characteristics and role in causing plant diseases.

Phycology: Algae in diversified habitats (terrestrial, freshwater, marine); thallus organization; cell, ultra-structure; reproduction (vegetative, asexual, sexual); criteria for classification of algae: pigments, reserve food, flagella; classification, salient features of protochlorophyta, Chlorophyta, Charophyta, Xanthophyta, Bacillariophyta, Phaeophyta and Rhodophyta; algal blooms, algal biofertilizers; algae as food, feed and uses in industry.

Unit II

Mycology: General characters of fungi; substrate relationship in fungi; cell ultra-structure; unicellular and multicellular organization; cell wall composition, nutrition (saprobic, biotrophic, symbiotic); reproduction (vegetative, asexual, sexual); heterothallism; parasexuality; recent trends in classification.

Phylogeny of fungi; general account of Mastigomycotina, Zygomycotina, Ascomycotina, Basidiomycotina; 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; Junger-maniales, Anthocerotales, Sphagnales, Funariales and Polytrichales; economic and ecological importance.

Pteridophyta: Morphology, anatomy and reproduction; classification; evolution of stele; heterospory and origin of seed habit; general account of fossil pteridophyta; introduction to Psilopsida, Sphenopsida and Pteropsida.

Suggested Readings

- Alexopoulos, C.J. Mims, C.W. and Blackwel, M. 1996. Introductory Mycology. John Wiley & Sons Inc.
- Clifton, A. 1958. Introduction to the Bacteria. McGraw-Hill Book Co., New York
- Kumar, H.D. 1988. Introductory phycology. Affiliated 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 Mahadevan, 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.R. 1991. The Morphology of Pteridophytes. B.I. Publishing Pvt. Ltd., Bombay.

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

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

Suggested Laboratory Exercises

Morphological study of representative members of algae, fungi, bacteria, bryophytes and pteridophytes: *Microcystis, Aulosira, Oocystis, Pediastrum, Hydrodictyon, Ulva, Pithophora, Stigeoclonium, Draperanaldiopsis, Closterium, Cosmarium, Chara, Stemonitis, Peronospora, Albugo, Mucor, Pilobolus, Yeast, Emericella, Chaetomium, Pleospora, Morchella, Melampyrum, Phallus, Polyporus, Drechslera, Phoma, Penicillium, Aspergillus, Colletotrichum, Marchantia, Anthoceros, Polytrichum, Psilotum, Lycopodium, Selaginella, Equisetum, Gleichenia, Pteris, Ophioglossum, Isoetes.*

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, Curvularia, Fusarium, Phoma, Colletotrichum, Graphium.*

Sterilization methods, preparation of media and stains.

PAPER III: TAXONOMY AND DIVERSITY OF SEED PLANTS

Duration: 3 hrs.

Max. Marks: 100

Note :- Each theory paper is divided into three independent units. The question paper is divided into three parts Part -A, Part -B and Part -C. Part A (20 marks) is compulsory and contains 10 questions (20 words each) at least three questions from each unit, each question is of two mark. Part -B (20 marks) is compulsory and contains four questions at least one from each unit. Candidate is required to attempt all four questions. Each question is of five marks (50 words). Part -C (60 marks) contains six questions two from each unit. Candidate is required to attempt three questions one from each Unit. Each question is of twenty marks (400 words).

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 Cycadeoidales and Cordaitales

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

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.

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

Unit III

Systems and phytogeography

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 utilization of bio-resources and ecosystem research.

Concept of Phytogeography: Endemism, hotspots and hottest hotspots; plant explorations invasions and introductions; local plant diversity and its socio-economic importance.

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 Specification. Columbia University Press, New York

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

Harrison, H.J 1971 New Concepts of Flowering Plant Taxonomy. Hieman Educational Books Ltd., London

Heslop - Harrison J. 1969 Plant Taxonomy. English Language Book Soc. & Edward Arnold Pub. Ltd. UK

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

ones, A.D and Willbins, A.D. 1971 Variations and Adaptations in Plant species. Hieman & Co. Educational Books Ltd., London.

ones, S.B. Jr. and Luchsinger, A.F 1986. Plant Systematics (2nd edition) McGraw-

Hill Book Co. New York

Nordenstam, B., El Gazaly, G. and Kassas, M. 2000 Plant Systematics For 21st Century. Portlant Press Ltd., London

Radford, A.E. 1986. Fundamentals Of Plant Systematics. Harper & Row Publications, USA

Singh, H. 1978. Embryology of Gymnosperms. Encyclopedia of Plant Anatomy X. Gerbruder Bortraeger, Berlin.

Anatomy X. Gebruder Bortraeger, Berlin.

Solbrig, O.T. 1970 Principles and Methods of Plant Biosystematics. The MacMillan Co.-Collier-MacMillan Ltd., London.

Solbrig, O.T. and Solbrig, D.J.-1979. Population Biology and Evolution.

Addison-Wesley Publication Co. Inc., 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 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. Comparafive 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 gymnosperms from prepared slides and specimens.

Angiosperms

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

PAPER IV: PLANT PHYSIOLOGY AND METABOLISM

Duration: 3 hrs.

Max. Marks: 100

Note:- Each theory paper is divided into three independent units. The question paper is divided into three parts Part -A, Part -B and Part -C. Part A (20 marks) is compulsory and contains 10 questions (20 words each) at least three questions from each unit, each question is of two mark. Part -B (20 marks) is compulsory and contains four questions at least one from each unit. Candidate is required to attempt all four questions. Each question is of five marks (50 words). Part -C (60 marks) contains six questions two from each unit. Candidate is required to attempt three questions one from each Unit. Each question is of twenty marks (400 words).

Unit I

Energy flow: Principles of thermodynamics, free energy and chemical potential, redox reactions, structure and functions of ATP.

Fundamentals of enzymology: General aspects, allosteric mechanism, regulatory and active sites, isozymes, kinetics of enzymatic catalysis, Michaelis-Menten equation and its significance. Membrane transport and translocation of water and solutes: Plant water relations mechanism of water transport through xylem, root-microbe interactions in facilitating nutrient uptake, comparison of xylem and phloem transport, phloem loading and unloading, passive and active solute transport, membrane transport proteins.

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

Unit II

Photochemistry and photosynthesis: General concepts and historical background, evolution of photosynthetic apparatus, photosynthetic pigments and light harvesting complexes, photo-oxidation of water, mechanisms of electron and proton transport, carbon assimilation-the Calvin cycle, photorespiration and its significance, the C4 cycle, the CAM pathway, biosynthesis of starch and sucrose, physiological and ecological considerations.

Respiration and lipid metabolism: Overview of plant respiration, glycolysis, the TCA cycle, electron transport and ATP synthesis, pentose phosphate pathway, glyoxylate cycle, alternative oxidase system, structure and function of lipids, fatty acid biosynthesis, synthesis of membrane lipids, structural lipids and storage lipids, and their catabolism.

Nitrogen fixation, nitrogen and sulphur metabolism: Overview, biological nitrogen fixation, nodule formation and nod factors, mechanism of nitrate uptake and reduction, ammonium assimilation, sulfate uptake, transport and assimilation.

Unit III

Sensory photobiology: History of discovery of phytochromes and cryptochromes, and their photochemical and biochemical properties, photophysiology of light-induced responses, cellular localization, molecular mechanism of action of photomorphogenic receptors, signaling and gene expression.

Plant growth regulators and elicitors: Physiological effects and mechanism of action of auxins, gibberellins, cytokinins, ethylene, abscisic acid, brassinosteroids, polyamines, jasmonic acid and salicylic acid, hormone receptors, signal transduction and gene expression.

The flowering process: Photoperiodism and its significance, endogenous clock and its regulation, floral induction and development-genetic and molecular analysis role of vernalization.

Stress physiology: Plant responses to biotic and abiotic stress, mechanisms of biotic and abiotic stress tolerance, HR and SAR, water deficit and drought resistance, salinity stress, metal toxicity, freezing and heat stress, oxidative stress.

Suggested Readings:

- Buchanan, B.B., Gruissem, W. and Jones, R.L. 2000. *Biochemistry and Molecular Biology of Plants*. American Society of Plant Physiologists, Maryland, USA.
- Dennis, D.T., Turpin, D.H. Lefebvre, D.D. and Layzell, D.B. (eds) 1997. *Plant Metabolism* (second edition). Longman, Essex England.
- Galston, A.W. 1989. *Life Processes in Plants*. Scientific American Library, Springer-Verlag, New York, USA.
- Hooykaas, P.J.J. Hall, M.A. and Libbenga, K.R. (eds) 1999. *Biochemistry and Molecular Biology of Plant Hormones*. Elsevier, Amsterdam, The Netherlands.
- 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.H. 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. *Physiochemical 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 Govindjee 1999. *Concepts in Photobiology: Photosynthesis and Photo morphogenesis*. Narosa publishing house, New Delhi.
- Taiz, L. and Zeiger, E. 1998. *Plant Physiology* (2nd edition). Sinauer Associates, Inc., Publishers, Maddachusetts, USA.
- Thomas, B. and vince-Prue, D. (1997) *Photoperiodism in Plants* (second edition). Academic press, San Diego, USA.

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_m value.
3. Demonstration of the substrate on activity of any enzyme nitrate reductase.
4. Extraction of chloroplast from leaves and preparation of the absorption spectrum of chlorophylls and carotenoids.
5. To determine the chlorophyll *a*/chlorophyll *b* ratio in C3 and C4 plants.
6. Isolation of intact chloroplasts and estimation of chloroplast proteins by spot protein assay.
7. Extraction of seed proteins depending upon the solubility.
8. 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.
9. 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.
10. Separation of isozymes of esterases, peroxidases by native polyacrylamide gel electrophoresis.
11. Principles of colorimetry, spectrophotometry and fluorimetry.

PAPER V: PLANT DEVELOPMENT AND REPRODUCTION

Duration: 3 hrs.

Max. Marks: 100

Note :- Each theory paper is divided into three independent units. The question paper is divided into three parts Part -A, Part -B and Part -C. Part A (20 marks) is compulsory and contains 10 questions (20 words each) at least three questions from each unit, each question is of two mark. Part -B (20 marks) is compulsory and contains four questions at least one from each unit. Candidate is required to attempt all four questions. Each question is of five marks (50 words). Part -C (60 marks) contains six questions two from each unit. Candidate is required to attempt three questions one from each Unit. Each question is of twenty marks (400 words).

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 devel-

opment.

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.

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.

Unit-II

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

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; in vitro fertilization.

Unit-III

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.

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:

Atwell, B.J. Kriedemann, P.E. and Irwin, C.G.N. (eds) 1999. *Plant in Action: Adaptation in Nature, performance in Cultivation*. MacMillan Education, Sydney, Australia.

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

Bhojwani, S.S. and Bhatnager, S.P. 2000. *The Embryology of Angiosperms* (4th revised and enlarged edition). Vikas Publishing House, New Delhi.

Burgess, J. 1985. *An Introduction to Plant Cell Development*. Cambridge University Press, Cambridge.

Fageri, K. and Van der Pijl, L. 1979. *The Principles of Pollination Ecology*. Pergamon Press, Oxford.

Fahn, A. 1982. *Plant Growth and Development. A Molecular Approach*. Academic Press, San Diego.

Howell, S.H. 1998. *Molecular Genetics of Plant Development*. Cambridge University Press, Cambridge.

Leins, P., Tucker, S.C. and Endress, P.K. 1988. *Aspects of Floral Development*. J. Cramer, Germany.

Lyndon, R.F. 1990. *Plant Development. The Cellular Basis*. Unwin Hyman, London.

Murphy, T.M. and Thompson, W.F. 1988. *Molecular Plant Development*. Prentice Hall, New Jersey.

Proctor, M. and Yeo, P. 1973. *The Pollination of Flowers*. William Collins Sons, London.

Raghavan, V. 1997. *Molecular Embryology of Flowering Plants*. Cambridge University Press, Cambridge.

Raghavan, V. 1999. *Developmental Biology of Flowering Plants*. Springer-verlag, New York.

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

Salisbury, F.B. and Ross, C.W. 1992. *Plant Physiology* (4th edition). Wadsworth Publishing, Belmont, California.

Steeves, T.I. and Sussex, I.M. 1998. *Patterns in Plant Development* (2nd edition). Cambridge University Press, Cambridge.

Sedgely, M. and Griffin, A.R. 1989. *Sexual Reproduction of tree Crops*. Academic Press, London

Waisel, Y., Eshel, A. and Kafkaki, U. (eds) 1996. *Plant Roots: The Hidden World* (2nd edition). Marcel Dekker, New York.

Shivanna, K.R. and Sawhney, V.K. (eds) 1997. *Pollen Biotechnology for Crop Production and Improvement*. Cambridge University Press, Cambridge.

Shivanna, K.R. and Rangaswamy, N.S. 1992. *Pollen Biology: A laboratory Manual*. Springer-Verlag, Berlin.

Shivanna, K.R. and Johri, B.M. 1985. *The Angiosperm Pollen: Structure and Function*. Wiley Eastern Ltd., New York. *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 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 cytohistological zonation in the shoot apical meristem (SAM) in sectioned and double-stained permanent slides of a suitable plant such as *Coleus*, *Kalanchoe*, tobacco. Examination of shoot apices in a monocotyledon in both T.S. and L.S. to show the origin and arrangement of leaf primordia.
5. Study of alternate and distichous, alternate and superimposed, opposite and decussate leaf arrangement. Examination of rosette plants (*Launea*, *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*, tobacco, *Nerium*, maize and wheat to understand the internal structure of leaf tissues and trichomes, glands etc. Also study the C3 and C4 leaf anatomy of plants.
7. Study of epidermal peels of leaves such as *Coccinia*, *Gaillardia*, *Tradescantia*, *Notonea*, 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 pollen grains for microscopic examination (maize, grasses, *Cannabis sativa*, *Crotalaria*, *Tradescantia*, *Brassica*, *petunia*, *Solanum melongena*, etc.).
11. Test 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 preparation; study of monosporic, bisporic and tetrasporic types of embryo sac development thorough examination of permanent, stained serial sections.

6. Field study of several types of flower with different pollination mechanisms (wind pollination, thrips pollination, bee/butterfly pollination, bird pollination).
17. Emasculation, Bagging and hand pollination to study pollen germination, seed set and fruit development using self compatible and obligate out crossing systems. Study of cleistogamous flowers and their adaptations.
18. Study of nuclear and cellular endosperm through dissections and staining.
19. Isolation of zygotic globular, 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 Readings:

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

PAPER VI: PLANT ECOLOGY AND ECONOMIC BOTANY**Duration: 3 hrs.****Max. Marks: 100**

Note :- Each theory paper is divided into three independent units. The question paper is divided into three parts Part -A, Part -B and Part -C. Part A (20 marks) is compulsory and contains 10 questions (20 words each) at least three questions from each unit, each question is of two mark. Part -B (20 marks) is compulsory and contains four questions at least one from each unit. Candidate is required to attempt all four questions. Each question is of five marks (50 words). Part -C (60 marks) contains six questions two from each unit. Candidate is required to attempt three questions one from each Unit. Each question is of twenty marks (400 words).

Unit I

Climate, soil and vegetation patterns of the world: life zones, major biomes, major vegetation and soil types of the world.

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

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

Climate change: Greenhouse gases (CO₂, CH₄, N₂O, CFCs: sources,

trends and role): ozone layer and ozone hole; consequences of climate change (CO₂ fertilization, global warming, sea level rise, UV radiation)

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 spots; inventory.

Air, water and soil pollution: Kinds; sources; quality parameters; effects on plants and ecosystems.

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

Ecological management: Concept; sustainable development; sustainability indicator.

Unit-III

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

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.

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 for 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 & Industrial Research (CSIR), and the Department of Biotechnology (DBT), for conservation, non-formal conservation efforts.

Suggested Readings:

Smith, R.L 1996. Ecology and Field Biology. Harper Collins, New York. Muller-Dombois, D. and Ellenberg, H. 1974. Aims and Methods of Vegetation Ecology, Wiley, New York.

Begon, M., Harper, J.L. and Townsend, C.R. 1996. Ecology. Blackwell Science,

Cambridge, U.S.A.

Ludwig, J. and Reynolds, J.F. 1988. Statistical Ecology. John Wiley & Sons.

Odum, E.P. 1971. Fundamental of Ecology. Saunders, Philadelphia.

Odum, E.P. 1983. Basic Ecology. Saunders, Philadelphia.

Barbour, M.G. Burk, J.H. and Pitts, W.D. 1987. Terrestrial Plant Ecology. Benjamin/Cummings Publication Company, California.

Kormody, E.J. 1996. Concepts of Ecology. Prentice-Hall of India pvt, Ltd., New Delhi.

Chapman, J.L. and Reiss, M.J. 1988. Ecology: Principles and Applications. Cambridge University Press, Cambridge, U.K.

Moldan, B. and Billharz, S. 1997. Sustainability Indicators. John Wiley & Sons, New York.

Treshow M. 1985. Air pollution and Plant life. Wiley Interscience.

Heywood, V.H. and Watson, R.T. 1995. Global Biodiversity Assessment. Cambridge University Press.

Mason, C.F. 1991. Biology of Freshwater Pollution. Longman.

Hill, M.K. 1997. Understanding Environmental Pollution. Cambridge University Press.

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 sides 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.
4. To determine minimum size and number of quadrates required for reliable estimate of biomass in grasslands.
5. To find out association between important grassland species using Chi-square test.
6. To compare protected and unprotected grassland stands using community coefficients (similarity indices).
7. To analyze plant communities using Bra-Curtis ordination method.
8. To determine diversity indices (Shannon-Wiener, concentration of dominance, species richness, equitability and B-diversity) for protected and unprotected grassland stands.
9. To estimate IVI of the species in a woodland using point centered quarter method.
10. To determine gross and net phytoplankton productivity by light and dark bottle method.
11. To determine soil moisture content, porosity and bulk density of soils collected from varying depths at different locations.

12. To determine the water holding capacity of soils collected from different locations.
13. To determine percent organic carbon and organic matter in the soils of cropland, grassland and forest.
14. To estimate the dissolved oxygen content in eutrophic and oligotrophic water samples by azide modification of Winkler's method.
15. To estimate Chlorophyll content in SO₂ fumigated and unfumigated plant leaves.
16. To estimate rate carbon dioxide evolution from different soils using soda lime of alkali absorption method.
17. To study environmental impact of a given developmental activity using checklist as a EIA method.

Suggested Readings:

Anonymous 1997. National Gene Bank. Indian Heritage on Plant Genetic Resources (Booklet). National Bureau of Plant Genetic Resources, New Delhi.

Arora, R.K. and Nayar, E.R. 1984. Wild relatives of crop Plants in India. NBPGR Science Monograph No. 7.

Baker, H.G. 1978. Plants and Civilization (3rd ed). C.A. Wadsworth, Belmont.

Bole, P.V. and Vaghain, Y. 1986. Field Guide to Common Indian Trees. Oxford University Press, Mumbai.

Chandel, K.P.S., Shukla, G. and Sharma, N. 1996. Biodiversity in Medicinal and Aromatic plants in India. Conservation and Utilization. National bureau of Plant Genetic Resources, New Delhi.

Chrispeels, M.J. and Sadava. D. 1977, Plants Food and People. W.H. Freeman and Co., San Francisco.

Cristi, B.R. (ed.) 1999. CRC Handbook of Plant Sciences and Agriculture Vol 1. In-situ conservation CRC Press, Boca Raton, Florida, USA

Conway, G. 1989. the Doubly Green Revolution: Food for All in the 21st Century. Penguin Books.

Conway, G. and Barbier, E. 1990 After the Green Revolution. Earth scan Press London.

Conway, G. and Barbier, E. 1994. Plant, Green and Agriculture. Jones and Bartlett publishers, Boston.

Council of Scientific & Industrial Research 1986. The Useful Plants of India. Publication and Information Directorate, CSIR New Delhi.

Council of Scientific & Industrial Research (1948-1976). The wealth of India. A Dictionary of Indian Raw Materials and Industrial Products. New Delhi . Raw Materials I-XII, Vol I-III (1985-1992) Supplement (2000).

Cronquist, A., 1981 An Integrated System of Classification of Flowering plants . Columbia University Press, New York. USA.

Directory of Indian Wetlands, 1993. WWF INDIA, New Delhi and AWB, Kuala Lumpur.

Falk, D.A. Olwell, M. and Millan C. 1996. Restoring Diversity. Island Press,

Columbia, USA.

FAO/IBPGR 1989. Technical Guidelines for the safe movement of Germplasm . FAO/ABPGR, Rome.

Frankel, O.H., Brown, A.H.D & Burdon, J.J. 1995. The Conservation of Plant Diversity. Cambridge University Press, Cambridge U.K.

Gadgil, M. and Guha, R. 1996. Ecology and Equity: Use and Abuse of Nature in Contemporary India. Penguin, New Delhi.

Gaston, K.J. (Ed). Biodiversity: a Biology of Numbers and Differences. Blackwell Science Ltd. Oxford, U.K.

Heywood. V. (Ed) 1995. Global Biodiversity Assessment. United Nations Environment Programme. Cambridge University press, Cambridge, U.K.

Heywood. V.H. and Wyse Jackson, P.S.(Eds) 1991. Tropical Botanical Gardens. Their Role in Conservation and Development. Academic Press, San Diego.

Kocchar, S.L. 1998. Economic Botany of the Tropics, 2nd edition. Macmillan India Ltd., Delhi.

Kothari, A. 1997, Understanding Biodiversity: Life Sustainability and Equity. Orient Longman.

Kohli, R., Arya, K.S., Singh, P.H. and Dhillon, H.S. 1994. Tree Directory of Chandigarh. Lovedale Educational, New Delhi.

Cambridge.

Nair, M.N.B. et al (Eds) 1998. Sustainable Management of Non-wood Forest Products. Faculty of forestry, University Putra Malaysia. 434004 PM Serdong, 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.

Pimentel, D. and Hall, C.W. (Eds) 1989. Food and Natural Resources. Academic Press, London-New York.

Pinstrup-Anderson, P. et al. 1999. World Food Prospects: Critical Issues for the Early 21st Century. International Food Policy Research Institute, Washington, D.C., USA.

Plant Wealth of India 1997. Special Issue of Proceedings Indian National Science Academy B-63.

Plucknett, D.L., Simth, N.J.H., William, J.T. and Murti Ammishetty, N. 1987. Gene Banks and Worlds Food. Princeton University Press, Princeton, New Jersey, USA.

Rodgers, N.A. and Panwar, H.S. 1988. Planning a wildlife protected Area Network in India. Vol. 1. The Report. Wildlife Institute of India, Dehredun. 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.

Thakur, R.S., Puri, H.S. and Husain, A. 1989. Major Medicinal Plants of India. Central Institute of Medicinal and Aromatic Plants, CSIR, Lucknow.

Thomas, P. 2000 trees: Their National History. Cambridge University Press, Cambridge.

Wagner, H., Hikino, H, and Fanswarth, N. 1989. Economic and Medicinal Plant Research. Vols 1-3 Academic Press. London.

Walter, K.S. and Gillett, H.J. 1998. 1997 IUCN Red List of Threatened Plant. IUCN, the World Conservation Union. IUCN. Gland, Switzerland, and Cambridge U.K.

Suggested Laboratory Exercises:

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

Laboratory work:

1. **Food crops:** Wheat, rice, maize, chickpea (Bengal gram), potato, tapioca, sweet-potato, sugarcane. Morphology, anatomy, micro-chemical tests for stored food materials.
2. **Forage/fodder crops:** Study of any five important crops of the locality (for example fodder Sorghum, berseem, clove, guar bean, gram, Ficus sp.)
3. **Plant fibers :**
 - (a) Textile fibers : cotton, jute, linen, sun hemp, Cannabis
 - (b) Cordage fibers : coir
 - (c) Fibers for stuffing : silk cotton or kapok

Morphology, anatomy, microscopic study of whole fibers using appropriate staining procedures.
4. **Medicinal and aromatic plants:** Depending on the geographical location college/university select five medicinal and aromatic plants each from a garden crop field (or from the wild only if they are abundantly available).
Papaver somniferum, Atropa belladonna, Catharanthus roseus, Adhatoda ceylanica. syn. A. vasica.
Allium sativum, Rauvolfia serpentina, Withania somnifera, Phyllanthus amarus, (P. fraternus), Andrographis paniculata, Aloe barbadense, 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.
5. **Vegetable oils:** Mustard, groundnut, soybean, coconut, sunflower, castor. Morphology, microscopic structure of the oil-yielding tissues, tests for oil and iodine number.

6. **Gums, resins, tannins, dyes:** Perform simple tests for gums and resins. Prepare a water extract of vegetable tannins (*Acacia, Terminalia*, tea, *Cassia* spp, myrobalans) and dyes (turmeric, *Bixa orellana*, indigo, *Butea monosperma, Lawsonia inermis*) and perform tests to understand their chemical nature.

Field Survey

7. **Firewood and timber-yielding plants and NWFP's**
 - A. 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.
 - B. Prepare an inventory of the bamboos and rattans of your area giving their scientific and local names and their various uses with appropriate illustrations!
 - C. 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/NGO's/ or civic authorities.
 The purpose of exercise in item C above is making the students aware of the kinds of trees and value in urban ecosystems and ecological services.

Scientific Visits*

The students should be taken to one of the following:

- i. A protected area (biosphere reserve, national park, or a sanctuary)
- ii. A wet land
- iii. A mangrove /Desert region
- iv. National Bureau of Plant Genetic Resources, New Delhi-110012 or one of its field stations.
- v. Head Quarters of the Botanical Survey of India or one of its Regional Circles.
- vi. A CSIR Laboratory doing research on plants and their utilization
- vii. An ICAR Research Institute or a field station dealing with one major crop or crops.
- viii. A recognized botanical garden or a museum (such as those at the Forest Research Institute, Dehra Dun; National Botanical Research Institute, Lucknow; Tropical Botanical Garden and Research Institute, Trivandrum), which has rich collection of plant products.

PAPER VII: BIOTECHNOLOGY AND GENETIC ENGINEERING OF PLANTS AND MICROBES

Duration: 3 hrs.

Max. Marks: 100

Note :- Each theory paper is divided into three independent units. The question paper is divided into three parts Part -A, Part -B and Part -C. Part A (20 marks) is compulsory and contains 10 questions (20 words each) at least three questions from each unit, each question is of two mark. Part -B (20 marks) is compulsory and contains four questions at least one from each unit. Candidate is required to attempt all four questions. Each question is of five marks (50 words). Part -C (60 marks) contains six questions two from each unit. Candidate is required to attempt three questions one from each Unit. Each question is of twenty marks (400 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.

Somatic hybridization: Protoplast isolation, fusion and culture, hybrid selection and regeneration, possibilities, achievements and limitations of protoplast 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.

Unit II

Recombinant DNA technology: Gene cloning principles and techniques, construction of genomic/cDNA library, choice of vectors, DNA synthesis and sequencing, polymerase chain reaction, DNA fingerprinting.

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.

Unit-III

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

Genomics 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,

Suggested Readings:

- Bhojwani, S.S. and Razdan, M.K. 1996. Plant Tissue Culture: Theory and Practice (a revised edition) Elsevier Science Publishers, New York, USA.
- Bhojwani, S.S. 1990. Plant Tissue Culture: Applications and Limitations. Elsevier Science Publishers, New York, USA.
- Brown, T.A. 1999. Genomes. John Wiley & Sons (Asia) Pvt. Ltd. Singapore.
- Callow, J.A., Ford-Lloyd, B.V. and Newbury, H.J. 1997. Biotechnology and Plant Genetic Resources: Conservation and use. CAB International, Oxon, UK.
- Chrispeels, M.J. and Sadava, D.E. 1994. Plants, and agriculture Jones & Bartlett Publishers, Boston, USA.
- Collins, H.A. and Edwards, S. 1998. Plant Cell Culture. Bios Scientific Publishers, Oxford, UK.
- Glazer, A.N. and Nikaido, H. 1995. Microbial Biotechnology. W.H. Freeman & Company, New York, USA.
- Gustafson, J.P. 2000. Genomes, Kluwer Academic Plenum publishers, New York, USA.
- Henry, R.J. 1997. Practical Applications of Plant Molecular Biology. Chapman & Hall, London, UK.
- Jain, S.M., Sopory, S.K. and Veilleux, R.E. 1996. In Vitro Haploid production in Higher Plants, Vols. 1-5, Fundamental Aspects and Methods. Kluwer Academic Publishers, Dordrecht, the Netherlands.
- Jolles, O. and Jornvall, H. (eds) 2000. Proteomics in Functional Genomics. Birkhauser Verlag, Basel, Switzerland.
- Kartha, K.K. 1985. Cryopreservation of Plant Cells and Organs. CRC Press, Boca Raton, Florida, USA.
- Old R. W. and Primrose, S.B. 1989. Principles of Gene Manipulation. Blackwell Scientific Publications, Oxford, UK.
- Primrose, S.B. 1995. principles of Genome Analysis. Blackwell Science Ltd., Oxford, UK.
- Raghavan V. 1986. Embryogenesis in Angiosperms: A Developmental and Experimental Study. Cambridge University Press, New York, USA.
- Raghavan V. 1997. Molecular Biology of Flowering Plants. Cambridge University Press, New York, USA.
- Shantharam, S. and Montgomery, J.F. 1999. Biotechnology, Biosafety, and Biodiversity. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi.
- Vasil, I.K. and Thorpe, T.A. 1994. Plant Cell and Tissue Culture. Kluwer Academic Publishers, The Netherlands.
- Suggested Laboratory Exercises**
1. Growth characteristics of *E. coli* using plating 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 vari-

- ous 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 dideoxy 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.

M.SC. (FINAL) BOTANY

ELECTIVE PAPER

PAPER VIII (1): ADVANCED PLANT PATHOLOGY

Duration: 3 hrs.

Max. Marks: 100

Note :- Each theory paper is divided into three independent units. The question paper is divided into three parts Part -A, Part -B and Part -C. Part A (20 marks) is compulsory and contains 10 questions (20 words each) at least three questions from each unit, each question is of two mark. Part -B (20 marks) is compulsory and contains four questions at least one from each unit. Candidate is required to attempt all four questions. Each question is of five marks (50 words). Part -C (60 marks) contains six questions two from each unit. Candidate is required to attempt three questions one from each Unit. Each question is of twenty marks (400 words).

Unit-I

Principles and Techniques: Phenomenon of plant infection penetration post infection development, factors affecting infection defence mechanisms. Inoculum potential, epiphytotics and disease forecasting physical control, chemical control, plant quarantines
Techniques of isolation, purification, culture and inoculation of pathogens, Histopathology, microscopes and measurements, photographs and illustrations (camera lucida drawings)

Unit-II

Fungi, diseases: Symptomatology and disease identification
Some important diseases like kernel bunt and flag smut of wheat, brown spot and bunt of paddy, ergot, smut and green ear disease of bajra, Red rot of sugarcane; wilt of cotton; Early and late blight of potatoes; Tikka disease of groundnut and powdery mildew of grapes.

Bacterial diseases: Symptomatology and methods of identification of bacterial pathogens.

Study of diseases like Brown rot and ring rot of potatoes; Tundu diseases of wheat, soft rot of vegetable, red stripe of sugarcane. Crown gall disease and citrus canker. **Virology:** Symptomatology and transmission of viral diseases

Study of viral diseases: Bunchy top of bannaner, Bhindi yellow mosaic.

Unit-III

Nematology: Methods used in Nematology

Nematode diseases: Ear cockle of wheat; root rot of vegetables and Molya disease of wheat

Ceycidology: classification and anatomy of galls.

Some insect induced plant galls of Rajasthan like *Pongamia* leaf gall.

30 / M.D.S.U. Syllabus / M. Sc. Botany

Cordia leaf gall, Zizyphus stem gall, Prosopis stem gall. Mechanism and physiology of insect galls.

Suggested Readings:

1. Alexopoulos, C.J. 1980. Introductory Mycology. Wiley Eastern Ltd., New Delhi, Bangalore, Bombay, Kolkata.
2. Alexopoulos, C.J. C.W. Mims and M.Blackwell 1996 Introductory Mycology 4th Edition Wiley, New York.
3. Agrios, N.George 2004 Plant pathology Academic press. Elsevier, DW of Read Elsevier Pvt. Ltd. New Delhi.
4. Bilgrami, K.S. And H.C. Duke 1997 A text Book of Modern plant pathology. Vikas Perb House. New Delhi.
5. Chatopadhyay. S.B. and N.samajpati 1982 Advances in Mycology and plant pathology Oxford & IBH Perb Co. New Delhi.
6. Hotton, C.S.1967 G.W/ Fisher: R.W. Fulton. Helen Hart: S.E.A. Macclan 19 Plant pathology problems & programmes Central Book Depot. Allahabad.
7. Harry, W; Seclay, J.G; Paul and Vodemark. 1975. Microbes in Action-A lab manual of Microbiology.
8. James, C. Cappucino. and N.Sharma 1999. Microbiology- A lab Manual.
9. Kaushik, P 1996 Introductory Microbiology Emkay Pub. New Delhi.
10. Mehrotra. R.S.1987 Plant pathology. Tata Macgrawthlll Pub. Co.Ltd. N.Delhi
11. Nagarajan, S.1983. Plant disease epidemiology to IBH perb.co. N. Delhi. Bombay, Kolkata.
12. Purohit S.S. 2002 Microbiology- Fundamentals & applications Agrobios (India) Pub. Jodhpur.
13. Ray chaudhari 1977 Versus & Mycoplasma diseases Oxford & IBH Perb Co, N. Delhi Bombay Kolkata.
14. Ramakrishnan, J.S. 1971 Diseases of Millets ICAR N.Delhi.
15. Sasser, J.N. and W.R. Jenkras Ed. 1975 Nematology Euvasia pub Housing (P) Ltd. New Delhi.
16. Singh, R.s. 1982 Plant pathogens (The fungi) Oxford & IBH Perb.Co. New Delhi. Bombay, Kolkata.
17. Singh, R.S. 1985 Diseases of Vegetable crops. Oxford & IBH Perb Co. N.Delhi , Bombay, Kolkata.
18. Southry, J.F. 1970 plant Nematology S. Chand & co. N. Delhi.

Suggested Laboratory Exercises

1. Culture transfer technique
2. Techniques for isolation of pure culture
3. Isolation of discrete colonies from a mixed culture.
4. Isolation of pure culture from a spread plate or streak plate preparation.
5. Culture characteristics of micro organisms.

6. Grams staining.
7. To draw camera lucida drawings of fungal spores.
8. Study of various fungal diseases: flag smut of wheat, Green ear disease of bajra, red rot of sugarcane, wilt of cotton, Early and late blight of potatoes, Tikka disease of groundnut & downy and powdery mildew of grapes.
9. Study of various bacterial diseases: soft rot of vegetables, red stripe of sugarcane, crown gall disease and citrus canker. List of Practicals
- Advanced plant paths
10. Study of viral diseases: Cucumber mosaic, bunchy top of banana, Bhindi yellow mosaic.
11. Study of Nematode diseases: Ear cockle of wheat, root rot of vegetables and Molya disease of wheat.
12. Study of galls: Pongamia and Cordia leaf galls and Zizyphus and Prosopis stem galls.

PAPER VIII (2): ADVANCED PLANT PHYSIOLOGY

Duration: 3 hrs.

Max. Marks: 100

Note :- Each theory paper is divided into three independent units. The question paper is divided into three parts Part -A, Part -B and Part -C. Part A (20 marks) is compulsory and contains 10 questions (20 words each) at least three questions from each unit, each question is of two mark. Part -B (20 marks) is compulsory and contains four questions at least one from each unit. Candidate is required to attempt all four questions. Each question is of five marks (50 words). Part -C (60 marks) contains six questions two from each unit. Candidate is required to attempt three questions one from each Unit. Each question is of twenty marks (400 words).

Unit-I

Lipid metabolism: Classification of fats and oils, saturated and unsaturated fatty acids, fatty acid oxidations.

Coumarins and lignin's: Structure and synthesis, chemistry, distribution and function.

Vitamins: structure and function.

Metabolism of secondary metabolites:

Tannins: Distribution, synthesis and functions.

Unit II

Hallucinogens: Distribution chemistry and functions.

Alkaloids: Pyrrole, pyrrolidine, pyridini, solyacetyl, isoquinidine, tropane and indole alkaloids, their distribution, synthesis and function, saponins and sapogenins, sterols, steroids, steroidal alkaloids, their distribution syn-

thesis and function.

Cardiac glycosides: Auxins: discovery, structure, bioassay, biosynthesis, mode of action and function.

Unit-III

Gibberellins: Discovery, physiological effects, bioassay and responses of plants, biosynthesis, and mode of action

Cytokinins: Discovery, structure, biosynthesis, bioassay, physiological effect on plants and mode of action.

Synthetic growth retardants, their physiological effects and biochemistry. Growth inhibitors: Abscisic acid and related compounds: discovery, natural occurrence, physiological effects, biosynthesis and mode of action.

Ethylene: History, biological effects, biosynthesis and mode of action. Role of growth regulators on modern agriculture and horticulture.

Suggested Readings:

Biochemistry Peragamon Press Oxford

Buchanan, B.B. Grisussem, W and Jones R.L. 2000 Biochemistry and molecular Biology of plants. American society of plant physiologist, Maryland, U.S.A.

Dey. P. M. and Harborne 1997 Plant Biochemistry

Goodwin, T.W. and E.I. Mercer 1990 Introduction to plant

Harborne, J.B., Mabry T. and Mabsy H., 1975 The flavonoids, Chapman & Hall, London

Heltmann, E. 1970 Sterio Biochemistry, Academic Press, New York

Hess, Dieter, 1981, Plant Physiology. Narosa Publishing House, New Delhi

Hooykass P.J.J., Hall, M.A. and libbenga, K.r. (eds.) 1999 Buio chemistry and Molecular Biology of Plant Hormones, Elsevier, Amsterdam. The Netherland

Lea, P.J. and Leegood, R. C. 1999 plant Biochemistry and Molecular Biology.

2nd Edition John W. ley and Sons, Chichester, England

Moore, T.C. 1989 Biochemistry and physiology of plant Hormones, Springe verleg, New York,

Salisbury, F.B. and Ross, C.W. 1992 plant physiology, Wadsworth Publishing Co. Log.

Suggested Laboratory Exercises

- (1) Separation of Photosynthetic pigments using paper and column chromatography
- (2) Estimation of chlorophyll by DMSO Method
- (3) Calculation of iodine Number
- (4) Calculation of Acid value
- (5) Calculation of saponification value
- (6) Estimation of Total carotene
- (7) Estimation of xanthophylls & Carotene
- (8) Estimation if Anthocyanin pigment
- (9) Separation of Anthocyanin pigment by paper and thin layer chromatog-

raphy

(10) Estimation of Total Nitrogen by kjeldahl Method.

(11) Separation of different Phenolic Compounds.

(12) Separation of Terpenoids

(13) Separation of Nitrogen ous compounds.

(14) Effect of AA on the Elongation growth of Maize Coleoptile

(15) Split pea stem Test for IAA

(16) Effect of IAA on Root formation

(17) Effect of IAA on Root inhibition

(18) Effect of GA on Hypocotyl Elongation

(19) Effect of GA on Retardation of Leaf Senescence

(20) Bioassay of gibberellins by using lactuca seed germination

(21) Effect of GA and Amylase induction in Cereal grain

(22) Effect of cytokinin on chlorophyll Retention

(23) Induction of seed dormancy by ABA and Reversal by GA & cytokinin

(24) Induction of seed dormancy by ABA and Reversal by GA cytokinin

(25) Calculation of vitamin C

PAPER VIII (3) ADVANCED PLANT ECOLOGY

Duration: 3 hrs.

Max. Marks: 100

Note :- Each theory paper is divided into three independent units. The question paper is divided into three parts Part -A, Part -B and Part -C. Part A (20 marks) is compulsory and contains 10 questions (20 words each) at least three questions from each unit, each question is of two mark. Part -B (20 marks) is compulsory and contains four questions at least one from each unit. Candidate is required to attempt all four questions. Each question is of five marks (50 words). Part -C (60 marks) contains six questions two from each unit. Candidate is required to attempt three questions one from each Unit. Each question is of twenty marks (400 words).

Unit-I

Environment-Holistic concept- Impact of man on environment and ecosystem. Pollution and conservation, forests, agriculture, grazing lands, soil and water pollution. Urban and rural ecosystem. Role of international organizations - IUCN, UNEP, UNESCO. Equilibrium and non-equilibrium Thermodynamics. Living organisms as dissipative structures.

Deserts- their formation, topography, distribution, characteristics, water economy, hot and cold deserts. Rajasthan desert Geology, physiography, climate, soil, vegetables, saline tracts and vegetation. Plant communities in the deserts of Rajasthan. Soil erosion and reclamation. Desert stabilization techniques. Adaptations of plants to arid conditions. Edaphic and Biotic factors. The vegetation is arid zones. Reproductive capacity of deserts plants, seed

out put, germination, dormancy, mechanism of seed dormancy viability and perennation. Desert as an ecosystem.

Unit-II

Renewable and Non Renewable Energy - Renewable and Non-renewable energy sources. Fossil fuels-classification, composition, physico-chemical characteristics and energy content of coal, crude oil, natural gas, hydroelectric power nuclear Energy-fission and fusion. Radioactive waste Management. Energy conservation.

Biomass and bioenergy, biomass production, energy plantation, Energy and Microbes.

Waste treatment and Management technology- Production of microbial seeds. Use of bioaugmentation in waste treatment use of enzymes in waste treatment BOD sensor. Wastewater treatment and disposal Root Zone technology

Unit-III

Ecosystem– Concept, structure and function; Energetics, cybernetics, homeostasis. Flow of energy, cycling of materials, organic production in different types of ecosystems. Forest, grassland, fresh water and marine ecosystems. Natural and man made ecosystems. Energy basis of ecosystems.

Ecosystem analysis: models of population growth and interactions mineral resources and mine land reclamation, Environmental impacts of exploitation or minerals and mining activities with reference of Rajasthan. Mineral and population. Aravallis mining lands types of mine reclamation practices. Revegetation of mine spoils through plant fertilization and related practice. Environmental monitoring, Environmental Auditing and Environment impact assessment (EIA) system monitoring, its purpose or uses. Environmental health, education and ethics.

Suggested Readings:

1. Ambasht, R.S. 1988. A text book of plant Ecology students, trends & Co. Varanase.
2. Beral, SW, FD. Hole & E R J Mac Cracter. 1980. soil genesis and classification Oxford & IBH Pirb. Co. New Delhi, Kolkata.
3. Black, C.A. 1973. Soil plant Relationships Wiley Eastern P. Ltd., New Delhi.
4. Cloudsley, J.L. and Thompson 1974. Man & Biology of Arid Zones Edward Arnold Pub. Ltd.,
5. Cloudsley, J.L. and Thompson, 1974. Micro-ecology. Edward Arnold Pub. Ltd.,
6. Chaudhari, Nag, B.D. 1983. Interdiction to Environ. Management. Interprint New Delhi.
7. Foth, H.D. & L.M. Turk, 1972. Fundamentals of sent science wriiy Eestem Pub. Ltd., New Delhi.

8. Kumar, H.D. 1995. Modin concepts of Ecology Vikas publishing House, New Delhi.
9. Kormondy, J. Edward. 1974. Concepts of Ecology Prentice Hall of India, New Delhi.
10. Murthy, V.V.N. 1985. Land & Water Management Engineering Kalyan Publishers, New Delhi.
11. Odum, E.P. 1975. Ecology. Oxford & 2BH, Pub. New Delhi, Kolkata, Mumbai.
12. Pandey, S.C. G.S. Furi and J. Singh 1967. Research methods in plant Ecology Asia, Pub. House New Delhi.
13. Sen, Daved. N. 1978. concepts in Indian Ecology. S. Nager & Co. New Delhi.
14. Soil survey Maniacal 1969. by soil survey staff. Beiran of plant, soil and Agriculture Engraining. Oxford & IBH Pub. Co. New Delhi.
15. Sharma P.D. 2000. Ecology & Environment Rastogi Pub. Meerut.
16. Sir, D.N. 1990. Environ & Plant life in India desert Geobios International, Jodhpur.
17. Shukla, R.S. and P.S. Chandel, 1994. plant Ecology S. Chand & Co. New Delhi.
18. Sen, D.N. 1978. Ecology & Vegetation of India Desert.
19. Svizreher, V.M. and D.D. Logofet 1978. stability of Biological Communities Mir Pub. Moscow.

Suggested Laboratory Exercises:

- **Physicochemical Analysis of soil or water:**

Water Analysis

- **Chemical Oxygen Demand (COD)**
- **Biological Oxygen Demand (COD)**
- pH
- Total hardness
- Chloride by titration
- Phosphate by spectrophotometer
- Total residual Chlorine
- Conductivity using conductivity Meter
- Alkalinity (Carbonate and Bicarbonate)

Soil Analysis

- pH of soil using pH meter
- Soil composition/soil texture
- Soil Moisture content
- Percentage organic carbon of soil
- Sodium/ potassium by flame photometer
- Calcium, Magnesium by titration method

Study of soil microorganisms

Biological monitoring

36 / M.D.S.U. Syllabus / M. Sc. Botany

- **Macrophytes**
- **Phytoplankton / zooplankton**
- **Diversity indices – Shanon Wiener/Simpson's index etc.**
- **Measurement of pigments**

Solid Water analysis:

- **Physical composition (by weight)**
- **Moisture content**
- **Total organic carbon**
- **Nitrogen, phosphorus and potassium (NPK)**
- **Carbon, Nitrogen ratio (C: N ratio)**
- **pH**
- **Conductivity**

Different Modes of graphical representation of data

