

GONDWANA UNIVERSITY
GADCHIROLI

SYLLABUS

BOTANY

M.Sc. Part-II

Semester III & IV

M. Sc. Botany Syllabus

Semester IV

Course code/name: **Paper- XIII : Plant conservation, IPR and Ethnobotany**

Module I

Plant biodiversity – Concept of Biodiversity; Types (Species, Genetic, Ecosystem diversity. Present status in India

Origin of Biodiversity; values of Biodiversity; loss of Biodiversity.

Megabiodiversity Centers with special emphasis on Western Ghats and Indo-Burma region

Biodiversity and agriculture; Bioprospecting; commercial values of Biodiversity.

CBD – General account

Module II

IUCN – General account, categories, Commissions, role in conservation; Red Data Book

CITES – General account, CITES & International trade

Strategies for conservation

Protected areas concept: Sanctuaries, National parks, Man and Biosphere programme, Biosphere reserves

Tiger reserves with reference to Melghat Tiger Project, Tadoba Andhari Tiger Reserve and Pench)

Wetlands – Types, Importance, Measures taken for conservation at National and International levels, Ramsar Convention

Mangroves – Types, Zonations, Importance, Measures taken for conservation at National and International levels

Module III

Coral Reefs – Types, importance, artificial reefs, conservation measures

Legislative framework for protection

Principles and practices for *Ex-situ* conservation, Botanical gardens, Field Gene Banks, Seed Banks.

In-vitro repositories, Cryobanks,

General accounts and activities of national institutes like Botanical Survey of India (BSI), National Bureau of Plant Genetic Resources (NBPGR), Indian Council of Agricultural Research (ICAR), Department of Biotechnology (DBT) and their role in plant conservation

Module IV

Intellectual property right; patenting: basic requirement, novelty, public domain; plant variety protection act; farmers right protection act; WTO with reference to biotechnological affairs

Ethnobotany: Definition, scope and significance. Status in India Major tribes of Maharashtra – Madia, Korku, Gond, Bhil, Varli (information on customs, traditions, plants used as medicines, scarcity food); Important medicinal plants used by tribals in Vidarbha; Sacred groves and their role in conservation.

M. Sc. Botany Syllabus

Semester IV

Course code/name: **Paper- XIV : Plant resource utilization, Bioethics, Biosafety, Plant breeding and Biostatistics**

Module 1:

Centres of diversity of domesticated plants; Green revolution.

Important fire wood and timber yielding plants; qualities of timber plant, Non-wood forest products (NWFPs) such as Bamboos and rattans

Origin, evolution and uses of food crop (rice and pigeonpea), Fibre crop (Cotton, jute),

Vegetable oil yielding crop (Safflower, Sunflower), Sugar and biomass crop (Sugarcane, Beet)

Source, types and uses of – gums, resins, tannins and dyes

A brief account of major spices, condiments, narcotics, mastigatories and fumitories and beverages

Fodder and forage plants

Medicinal and aromatic plants

General account of petrocrops

Module 2:

Sampling-Sampling procedure, homogenization of samples, samples size, Selection of random sample, Limitation of analytical methods

Types of data, Frequency distribution, Measure of central values - Mean, median and mode, **Measures of dispersion** - range , mean deviation , standard deviation, coefficient of variation, moment, Statistical Inference of Qualitative & Quantitative Variables, level of significance, Chi square test & its applications, One-Way ANOVA, Two way ANOVA, t-test

Module 3:

Population genetics: Hardy-Weinberg equilibrium and deviations from it; quantitative trait loci (Kernel colour in wheat, corolla length in *Nicotiana longifera*).

Plant breeding: Methods of breeding sexually (self and cross pollinated) and vegetatively propagated crops; heterosis and inbreeding depression and their genetic basis; use of male sterility in hybrid production.

Bioethics: Professional ethics, ethical decision making and ethical dilemmas

Module 4:

Biosafety in the laboratory institution: Laboratory associated infections and other hazards, assessment of biological hazards and levels of biosafety, prudent biosafety practices in the laboratory/ institution

Biosafety regulations in the handling of recombinant DNA processes and products in institutions and industries, biosafety assessment procedures in India and abroad

Biotechnology and food safety: The GM-food debate and biosafety assessment procedures for biotech foods & related products, including transgenic food crops, case studies of relevance.

Ecological safety assessment of recombinant organisms and transgenic crops, case studies of relevance (Eg. Bt cotton).

Biosafety assessment of biotech pharmaceutical products such as drugs/vaccines etc.

International dimensions in biosafety: Cartagena protocol on biosafety, bioterrorism and convention on biological weapons

Suggested Readings :

1. Arora, P. N. & Malhon, P. K., 1996 Biostatistics. Himalaya Publishing House, Mumbai.
- 2.
3. Campbell, R. C. 1974 Statistics for Biologists. Cambridge University Press, Cambridge.
4. Cochran, W. G. Sampling Techniques, Wiley eastern Ltd, New Delhi.
5. Daniel, W.W. 2004, Biostatistics. 8th Edn. Wiley
6. Donald T. Haynie, Biological thermodynamics. Cambridge University Press, 1st edition.
7. Feller, W. Introduction to probability theory and its applications, Asia Publ. House, Mumbai.
8. Glover, T. and Mitchell, K. 2002, An introduction to Biostatistics. McGraw-Hill , N.Y.
9. Intellectual Property Rights - Brigitte Anderson, Edward Elgar Publishing
10. Intellectual Property Rights and the Life Sciences Industries - Graham Dutfield, Ashgate Pub.
11. WIPO Intellectual Property Handbook
12. Intellectual Property Rights - William Rodolph Cornish, David Clewelyn
13. Biotechnology-The science and the business Mosses V, Cape RE, 2nd edn., CRC press 2000.
14. Patterns of Entrepreneurship - Jack M. Kaplan
15. Indian Patents Law, Mittal, D.P. (1999) Taxmann, Allied Services (p) Ltd.
16. Handbook of Indian Patent Law and Practice - Subbaram , N. R. , S. Viswanathan (Printers and Publishers) Pvt. Ltd., 1998.

Websites: 1. Intellectual Property Today : Volume 8, No. 5, May 2001, www.iptoday.com

2. Using the Internet for non-patent prior art searches, Derwent IP Matters, July 2000. www.ipmatters.net/features/000707_gibbs.html

SPECIALIZATION

Molecular Biology and Plant Biotechnology

Semester IV

Course code/name: **Paper-XV : Molecular Biology and Plant Biotechnology (special) I**

Module I:

DNA replication: DNA replication in prokaryotic organism – Initiation, elongation, and termination, DNA replication in eukaryotes – origin, replication form, replication proteins, Comparative account of DNA replication in prokaryotes and eukaryotes, DNA replication proteins

DNA damage and repair: Types of DNA damage, factors for DNA damage,

Repair system: Single base change, direct repair, mismatch repair, SOS response.

Module II:

Isolation of gene and nucleotide sequence: DNA manipulation enzymes; General methods of gene isolation.

Molecular probing: Recombinant DNA libraries (gDNA and cDNA, oligonucleotide probes); nucleic acid hybridization (southern, northern, dot-blot and slot-blot); antibodies as probe for proteins (immunoblotting or western blotting, immunoprecipitation, southwestern screening).

Module III:

Splicing of foreign DNA into cloning vector: Vectors for prokaryotes; ligation.

Introduction of foreign DNA into host cell: Transformation; transfection; transgenesis

Isolation of genes or protein products from clones: Expression vectors- Characteristics; vectors producing fusion proteins

Polymerase chain reaction: Types of PCR's and their applications in molecular biology

Module IV:

Sequence alignment and phylogenetic trees: Dot plots, sequence similarity, pairwise and multiple alignment, significance of alignment, phylogeny and phylogenetic trees and evolution.

Genomics: Definition; genome analysis (genetic polymorphisms, genetic mutations); microarray technology and applications (gene expression and diseases).

Proteomics: Protein stability and folding; application of hydrophobicity; DALI (Distance-matrix alignment); Protein structure- evolution, classification, prediction and modeling, prediction of function. DNA microarrays, mass spectrometry, network and graphs, protein complexes and aggregates, protein interaction networks, regulatory networks.

Practicals:

1. Detection of DNA damage by mutagens
2. Bacterial transformation and selection of transformed cells.
3. To detect molecular polymorphism of different species
4. To demonstrate the presence of particular polypeptide by Western blotting.
5. To design PCR primers for isolation of given gene and to clone it in the given vector.
6. Amplification and sequencing of nr DNA by PCR
7. To find the sequences of a given protein in SWISS-Prot, Uni-Prot
8. To work out the sequence from given autoradiogram and to identify it from GeneBank by BLAST method.
9. To generate Pairwise and multiple sequence alignment of a given organisms
10. To generate phylogenetic tree using given sequences.
11. To predict a protein from given sequence by using online tools from NCBI.

Suggested Readings(for laboratory exercises)

1. Baxevanis, A. D. and Ouellate, B. F. F. 2009 Bioinformatics: A Practical Guide to the analysis of genes and proteins. John-Wiley and Sons Publications, New York.
2. Baxevanis, A. D., Davison, D. B.; Page, R. D. M.; Petsko, G. A.; Stein, L. D. and Stormo, G. D. 2008 Current Protocols in Bioinformatics.
3. McEntyre, J.; Ostell, J., editors Bethesda (MD) The NCBI Handbook: National Library of
4. Medicine (US), NCBI; 2002-2005
5. Sambrook and Russel. 2001. Molecular cloning Vol. 1-3 CSH press.
6. Tools & updated literature available at www.ncbi.com

References: Online journals available on UGC V-SAT programme.

Suggested Readings:

1. Alberts, Bruce; Johnson Alexander; Lewis, Julian; Raff, Martin; Roberts, Keith; Walter,
2. Peter, C. 2002 Molecular Biology of the Cell, Garland Science, New York and London.
3. Baxevanis, A. D. and Ouellate, B. F. F. 2009 Bioinformatics: A Practical Guide to the analysis of genes and proteins. John-Wiley and Sons Publications, New York.
4. Baxevanis, A. D., Davison, D. B.; Page, R. D. M.; Petsko, G. A.; Stein, L. D. and Stormo, G. D. 2008 Current Protocols in Bioinformatics
5. Bergman, N.H 2007 Comparative Genomics_Humana Press Inc., Part of Springer Science+ Business Media
6. Brown, T. A. 1999. Genomes, John Wiley & Sons(Asia) Pvt. Ltd., Singapore

7. De Robertis, E.D.P. and De Robertis, E.M.F. Cell and Molecular Biology 8th Ed. B. I. Waverly Pvt. Ltd., New Delhi.
8. Glover, D.M. and Hames, D.B 1995 DNA Cloning : A practical approach, R.L. Press, Oxford.
9. 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.
10. Jolles, O. and Jornvall, H. (eds) 2000. Proteomics in Functional Genomics. Birkhauser Verlag, Basel, Switzerland.
11. Karp, G. 1999 Cells and Molecular Biology; Concepts and Experiments. John Wiley & Sons, Inc., USA.
12. Lehninger' Principles of biochemistry-Nelson, Cox, 4th Edn., W.H.Freeman and Co.,2005.
13. Lewin, B. 2000 Gene VII Oxford Univ. press, New York.
14. Lewin, B. 2010 Gene X Oxford Univ. press, New York.
15. Lodish, H., Berk, A. Zipursky, S. L. Matsudaira, P., Baltimore, D. and Darnell, J. 2000 Molecular Cell Biology Edi. W.H. Freeman and Co., New York, USA
16. Mount W. 2004 Bioinformatics and sequence genome analysis 2nd Edi. CBS Pub. New Delhi
17. Old and Primrose , 1994, Principles of gene manipulation. Blackwell Scientific Publ.
18. Raymond Schuler and Zielinski, E. 2005, Methods in plants Molecular biology - Acad. Press.
19. Russel, P. J. 1998 Genetics (5th Edi.) The Benjamin/ Cummings Publishing Com. Inc., USA
20. Sambrook and Russel. 2001. Molecular cloning Vol. 1-3 CSH press.
21. Shaw, C.H. 2006, Plant Molecular Biology: A practical approach. Panima Pub. Corp.
22. Stryer, Berg, Biochemistry- 6th Edition, W. H. Freeman and Co.,2007.
23. Voet, D.; Voet, J.; Biochemistry – 3rd Edn. John Wiley and sonsInc., 2004.
24. Wilson Keith and Walker John 2005 Principles and techniques of biochemistry and molecular biology, 6th Ed. Cambridge University Press, New York.
25. Wolf, S.L. 1993. Molecular and Cellular Biology, Wadsworth Publishing Co., California, USA

M. Sc. Botany Syllabus

Semester IV

Course code/name: **Paper- XVI:(Molecular Biology and Plant Biotechnology(Special) II**

Module I:

Transgenics : Cloning vectors for higher plants; Methods for gene transfer, *Agrobacterium tumefaciens* mediated- Basis of tumor formation, features of Ti and Ri plasmids, mechanisms of DNA transfer, role of virulence genes, use of Ti and Ri genetic markers, use of reporter genes and introns; Direct DNA transfer; particle bombardment; electroporation; microinjection; macroinjection; liposomes; electrophoretic; pollen tube method; pollen transformation; PEG method; transformation of monocots; transgene stability and gene silencing; chloroplast transformation.

Module II:

Applications of transformation: Herbicide resistance; insect resistance; Bt genes, disease resistance; Nutritional quality; biopesticides and biofertilizers; hazards and safety regulations for transgenic plants.

Metabolic engineering through transgenic plants: Production of secondary metabolites; industrial enzymes; biodegradable plastics (PHB and any other); edible vaccines; antibody production and other important drugs.

Module III:

Plant tissue culture: History, Culture types: Callus culture, organ culture, suspension culture for production of secondary metabolites, protoplast culture, fusion and somatic hybrids, Somatic embryogenesis, anther and pollen culture, haploid plants, somaclonal variations, organogenesis (direct and indirect).

Gene expression: Gene expression in Mitochondria, chloroplast, yeast

Regulation of gene expression: Regulation of gene expression in translation and post-translation level

Module IV:

Nitrogen fixing genes: Organization, function and regulation of nitrogen fixing genes in *Klebsiella*, *hup* genes.

DNA fingerprinting and marker assisted breeding: RFLP maps; linkage analysis; RAPD markers; STS; SSR (microsatellites); ISSR; SCAR (sequence characterized amplified regions); SSCP (single strand conformational polymorphism); AFLP; QTL: map based cloning; molecular marker assisted selection

Cleaner Biotechnology: Pollution control through genetically modified organisms.

Practicals:

1. *Agrobacterium tumefaciens* mediating gene transfer in a suitable plant
2. Elisa testing of Bt gene in cotton
3. Induction of secondary metabolite synthesis in suspension culture.
4. Isolation of secondary metabolites by gel filtration.
5. Purification of plant metabolite/ protein by column chromatography.
6. Use of RAPD/RFLP/SSCP etc. markers to detect molecular polymorphism of different species.
7. Isolation and protein profiling in different plant species by SDS-PAGE.
8. Raising of suspension culture and plotting of growth curve.
9. Bacterial transformation and selection of transformed cells.
10. DNA ligation and analysis of ligated DNA on agarose gel (cloning and analysis using GUS gene.
11. Study of expression of inducible genes at biochemical level.
12. Organogenesis and somatic embryogenesis using appropriate explants and preparation of artificial seeds.
13. Demonstration of anther culture.

Suggested Readings (for laboratory exercises)

1. Gelvin, S. B. and Schilperoort, R. A (eds) 1994. Plant Molecular Biology Manual, 2nd edition. Kluwer Academic Publishers, Dordrecht, The Netherlands.
2. Glick, B. R. and Thompson, J. E. 1993, Methods in Plant Molecular Biology and Biotechnology. CRC Press, Boca Raton, Florida.
3. 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.
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, R. D. (Ed.), 1999. Plant Cell Culture Protocols. Humana Press. Inc. New Jersey, USA.
6. Maniatis et al. Molecular cloning Vol. I, II and III. Cold-Spring Harbor Lab Press.
7. Sambrook and Russel. 2001. Molecular cloning Vol. 1-3 CSH press.
8. Shaw, C. H. (Ed.) 1988, Plant Molecular Biology : A Practical Approach. IRL Press, Oxford.
9. Smith, R. H. 2000. Plant Tissue Culture : Techniques and Experiments. Academic Press, New York.

References: Online journals available on UGC V-SAT programme.

Suggested Readings:

1. Alberts, Bruce; Johnson, Alexander; Lewis, Julian; Raff, Martin; Roberts, Keith; Walter, Walter,
2. Bhojwani SS and Rajdhan MK 1996 Plant tissue culture: Theory and Practice. Elsevier Sci. Publ., New York
3. Peter c2002 Molecular Biology of the Cell, New York and London: Garland Science.
4. Callow, J. A., Ford-Lloyed, B. V. and Newbury, H. J. 1997. Biotechnology and Plant Genetic Resources: Conservation and Use, CAB International, Oxon UK.
5. Charlwood, B. Y. and Rhodes, M.V. 1999 Secondary products from plant tissue culture, Clarendon Press. Oxford.
6. Chrispeels, M. J. and Sadava, D. E. 1994, Plants, Genes and Agriculture. Jones & Barlett Publishers, Boston, USA.
7. Collins HA and Edwards S 1998 Plant cell culture. BIOS Sci. Publ., Oxford UK
8. Dicosmo F and Misawa, M. 1996 Plant Cell culture: Secondary metabolism towards industrial application, CRC press, Boca Raton, New York.
9. Glazer, A. N. and Nikaido, H. 1995. Microbial Biotechnology. W. H. Freeman & Company, New York, USA.
10. Gustafson, R. J. 2000. Genomes. Kluwer Academic Plenum Publishers, New York, USA.
11. Henry, R. J. 1997. Practical Applications of Plant Molecular Biology. Chapman & Hall, London, UK.
12. Jain SM, Sopory SK and Veilleux RE 1996 In vitro haploid production in higher plants. Vols. 1-5. Kluwer Acad. Publ., The Netherlands
13. Kurz, W.G.W 1989 Primary and Secondary metabolism of plant and Cell cultures, Springer Verlag, Berlin.
14. Old, R. W. and Primrose, S. B. 1989. Principles of Genome Analysis. Blackwell Scientific Publications. Oxford, UK.
15. Primrose, S. B. 1995. Principles of Genome Analysis. Blackwell Scientific Ltd., Oxford ,UK.
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 Publication Co., Pvt., Ltd., New Delhi.

SPECIALIZATION

Reproductive Biology of Angiosperms

Semester IV

Course code/name: **Paper XV : Reproductive Biology of Angiosperms (Special) I**

Module I:

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

Anther: Structure, anther wall;: endothecium, middle layer, tapetum-Structure, types-structure-function relationship, role of tapetum, microsporogenesis- sporogenous cells cytoplasmic reorganization during sporogenesis (Ultrastructural changes), molecular biology of meiosis, DNA and RNA synthesis, Protein synthesis, meiosis specific genes. Pollen tetrad development, pollen wall proteins, adaptive significance of pollen wall,

Module II:

Male gametophyte development: formation of vegetative and generative cells, differential behavior of sperms, gene expression during pollen development.

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

Module III:

Pistill: Carpel determination, ovule and its structural details.

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

Module IV:

Pollination-pollination mechanism, biotic and abiotic pollination, floral attractants and rewards,

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

Incompatibility: General concept, self incompatibility (Intraspecific type) heteromorphic, homomorphic types, mechanism of self compatibility, importance of self compatibility, methods of overcoming self incompatibility, Parasexual hybridization,

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Semester IV

Course code/name: **Paper XVI : Reproductive Biology of Angiosperms (Special) II**

Module I:

Fertilization: Cellular nature of sperm, the sperm cytoskeleton, the male germ unit, isolation and characterization of sperm, growth of the pollen tube through the style, passage of sperm into the embryo sac, fusion of nuclei, double fertilization, triple fusion, unusual features. In-vitro approaches to the study of fertilization-Intra-ovarian pollination, test tube fertilization, in-vitro fertilization, placental pollination, Gynogenesis.

Endosperm: types of endosperms, ruminant endosperm, cytological status. endosperm haustoria, chemical composition of endosperm, food reserve in endosperm, role of endosperm in embryo development, endosperm mutants.

Module II:

Embryogenesis: Zygote and its ultra-structure, milieu of the developing embryo, symmetry and polarity, rest period in zygote embryonic formulae, embryonic law.

Suspensor-Ultra structure of suspensor cells, cytology of suspensor cell, physiology and biochemistry of suspensor; Nutrition of embryo- nutrient supply of the zygote, embryo-endosperm relation.

Polyembryony: Definition, causes, classification, induction of polyembryony, practical importance of polyembryony.

Module III:

Apomixis: Definition, causes, classification, - Diplospory, Apospory, pseudogamy, autogamous development of endosperm, causes of apomixis, significance.

Parthenocarpy: Definition, causes, practical importance

Mellitopalynology : Pollen analysis of honey, Role of apiary in crop production.

Biotechnology: Concept and scope of biotechnology; Cell structure, cellular totipotency

Anther and pollen culture,

Ovule and nucellus culture

Endosperm culture and its practical applications

Embryo culture: Techniques, nutritional aspects of embryo culture morphological and physiological considerations, culture of mature embryo and proembryo.

Somatic embryogenesis: historical background, embryogenesis from callus, direct embryogenesis- recurrent embryogenesis; cytology of somatic embryogenesis, nutritional factors, hormonal factors.

Module IV:

Protoplast culture and somatic hybridization- isolation of protoplast, culture methods, fusion of protoplast, selection of fusion products, consequences of fusion, production of Cybrids and hybrids.

Biotransformation and production of useful compounds through cell culture, factor affecting yield, biotransformation, bioreactors, perspective.

Practicals :

- 1) Study from the permanent preparations.
 - a) Development and structures of anther pollen.
 - b) Structure of ovule, types, megasporogenesis, embryo sac types.
 - c) Development of endosperm, types.
 - d) Structure and development of embryo- types
 - e) Pericarp and seed coat structure from sections and macerations.
 - f) Sketching of ovular structure, embryo sac, anther wall, embryo with the help of camera lucida.
- 2) Techniques, Familiarity with phase contrast, polarizing, fluorescence and electron microscopy, wholemounts, fission and macerations, permanent double stained microtome sections, photo microscopy.
- 3) Preparation of dissected wholemounts of endothecium, tapetum, endosperm and embryo, squash preparations of tapetum, microspore mother cells, dyads, tetrads pollinia and massulae. Study of mitosis and meiosis and identification of various stages.
- 4) Study of different pollen using acetolysed and non acetolysed pollen, preparation of permanent slides for morphological study. (polarity, symmetry, shape, size, aperture, sporoderm stratification: minimum 15 slides to prepare).
- 5) Interpretation of electron micrographs (SEM, TEM) of pollen.
- 6) Short term exercises on pollen production, viability and their percentage of germination. Rate of growth of germ tube to be studied in a given period.
- 7) Viability of seed through germination, biochemical and excised embryo methods.
- 8) Cytology of pollen inhibition in self and interspecific incompatibility, application of some technique to overcome incompatibility.
- 9) Experiments on intra- ovarian pollination.
- 10) Experiments on plant tissue culture. Technique- washing. Sterilization, preparation of media, storage of media, inoculation, callus initiation, proliferation.
- 11) Responses of calli to stress condition viz. temp, (low, high), moisture, salinity.
- 12) Induction of androgenesis through anther culture.
- 13) Physiology of embryo development, using electrophoretic and histochemical methods embryo culture.
- 14) Somatic embryogenesis
- 15) Protoplast culture.

Suggested Readings:

1. Asker S. 1979, Progress in apomixis research. *Hereditas* 91, 231-240.
2. Barnier, G. 1986, The flowering process as an example of plastic development. *Soc. Expt.. Biol.* 40: 257-286.
3. Barth, F.G. 1991, insects and flowers, Princeton Univ. Press. Princeton.
4. Battaglia, E. 1963. Apomixis In recent advances in the embryology of angiosperms (ed P. Maheshwari), pp- 264, *Intt. Soc. Plant Morphologists, Univ. Delhi.*
5. Bhandari N. N. 1984, The microsporangium in embryology of angiosperms (ed B.M. Johri) Springer- Verlag, Berlin, pp. 53-121.
6. Bhandari N.N., M. Bhargava and P. Chitralkha 1986, Cellularization of free nuclear endosperm of *Pappaver somniferum* L. *Phytomorphology*, 36, 357-366.
7. Bhojwani S.S. and M.K. Rajdan 1983, Plant tissue culture, Theory and Practice Elsevier, Amsterdam.
8. Boesewinkel F.D. and Boman F. 1984, The seed structure in embryology of angiosperms (ed B.M.Johri), Springer- Verlag, Berlin, pp. 567-610.
9. Bouman F. 1984 The ovule in embryology of angiosperms (ed B.M.Johri), Springer-Verlag, Berlin, pp. 123-157.
10. Cartson P.S., Smith N.H., Dearing R.D. (1972) Parasexual interspecific plant hybridization. *Proc. Nat. Acad. Sci. USA*, 69, 2292-2294.
11. Cartson P.S. (1973) The use of protoplasts of genetic research. *Proc. Nat. Acad. Sci. USA*, 70, 598-602.
12. Chitralkha P. and N.N. Bhandari 1991, Post fertilization development of antipodal cells in *Ranunculus scferatus*. *Phytomorphology* 41, 200-212.
13. Ciampolini F.M., Nepi and E. Pacini 1993, tapetum development in *Cucurbita pepo* (Cucurbitaceae) *Pt. Syst. Evol. (Suppl)* 7-13-22.
14. Cocking E.C. 1960, A method for the isolation of plant protoplasts and vacuoles. *Nature (London)* 187-927-929.
15. Cocking E.C. 1970, Virus uptake, cell wall regeneration and virus multiplication in isolated plant protoplasts. *Int. Rev. Cytol* 28-89-124.

SPECIALIZATION

Mycology and Plant pathology

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Semester IV

Course code/name: **Paper- XV : Mycology and Plant pathology (special) I**

MODULE I: General Microbiology :

Bacteria – Morphology, size, shape, structure, Characters of Eubacteria, Actinomycetes, Archaeobacteria, Bacterial nutrition, reproduction.

Viruses – General Characteristics, structure, classification (LHI System), replication (lytic cycle & lysogeny)

Rickettsia – General characters

MODULE II: Mycorrhiza :

Kinds of mycorrhizae : Ectotrophic and endotrophic mycorrhizae, their morphology and anatomy. V A - mycorrhiza. Importance of mycorrhiza in Agriculture.

Rhizosphere and phyllosphere - General concept and importance.

Medical Mycology - Dermatophytic fungi - Knowledge of common dermatophytes and human diseases caused by them viz. *Tinea pedis*, *Tinea capitis*, *Tinea barbae*, *Tinea corporis* and *Tinea manuum*, Non-dermatophytes.

MODULE III: Production of Metabolites By Fungi:

Industrial Fungal Metabolites:

Antibiotics - Penicillin, Cephalosporin, Griseofulvin, Industrial production. of Penicillin

Enzymes -. Amylase, proteases, Lipases, Pectinases, Cellular and xylanases.

Organic acids - Citric acid, Gluconic acid, lactic acid, kojic acid. Itaconic acid.

Non Industrial Fungal Metabolites :

i) Phytoalexins ii) Mycotoxins

MODULE IV :Fungi as welfare to human beings:

Fungi in food processing

Fungi in Medicine

Fungi as food - edible mushrooms, methods of their cultivation and economic importance.

Concept of biodeterioration and Biodegradation

Biodeterioration of noncellulosic materials.

Biodeterioration of cellulosic materials.

Role of microorganisms in Biodegradation of organic wastes. Factors affecting the process of Biodegradation.

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Semester IV

Course code/name: **Paper- XVI : Mycology and Plant Pathology (special) II**

Module 1:

History : Milestones in phytopathology with particular reference to India. Major epidemics and their social impacts. Historical developments of chemicals, legislative, cultural and biological protection measures including classification of plant diseases.

Physiological and Molecular Plant Pathology

Altered metabolism of plants under biotic and abiotic stresses. Molecular mechanisms of pathogenesis: recognition phenomenon, penetration, invasion, primary disease determinant.

Module II: Principles of Plant pathology

Principles of plant pathology- Importance, nature, classification and general symptoms of plant diseases.

Koch's Postulates: Pathogenicity of microorganisms and pathogenesis.

Host parasite relationship and Interaction, mechanism of infection, path of infection. .

Defence mechanism in host plants against pathogens - morphological or structural defence mechanism, Biochemical defence mechanisms, defence, role of phenolic compounds, enzymes and toxins,

Epidemiology and forecasting of plant diseases- the form of epidemic conditions for decline of epidemic, methods used in forecasting. .

Principles and methods of plant disease control - cultural methods, chemical methods, Biological control , integrated pest management (IPM), Biopesticides.

Module III :

A Detailed study of the Diseases of the following crops caused by fungal pathogens with effective control measures.

Diseases of Cereals :

Seedling blight of cereals, Smut of wheat, Foot rot of wheat, Loose smut, Covered smut of Barley, False smut of rice, Leaf spot of rice, Downey mildew of jowar, Green ear disease of Bajra, Ergot of Bajra, Downey mildew of maize.

Diseases of Vegetable crops with special reference to the important diseases of the following:

Chilli, Brinjal, Tomato, Potato, Coriander, Ginger, Onion, Bhindi.

General knowledge of post harvest diseases of fruits and vegetables and their control.

Diseases of Oil Seed Crops:Viz. - Linum, Sesamum, Groundnut, Mustard and Sunflower

Diseases of Fruit Trees-

With special reference to important diseases of the following Citrus, Apple, Mango, Papaya., Banana and Grapes.

Module- IV :Bacterial Diseases of Plants:

Important Pathological aspects of the following bacterial diseases.

Bacterial blight of rice, Tundu disease of wheat, Angular leaf spot of cotton, stalk rot of maize, Fire blight of Apple, Bacterial soft rot of fruits and Vegetables. .

Viral Diseases of Plant :

Bunchy top of Banana, Leaf curl of Papaya, Yellow vein mosaic of Bhindi. Mosaic of .Cucurbits, Viral diseases of Tobacco, Potato and Tomato.

Mycoplasma Diseases of Plants :

Citrus greening, Rice yellow dwarf: Little leaf of Brinjal, Sandal Spike.

Nematode Diseases of Plants :

General knowledge of plant parasitic nematodes and Important nematode diseases viz. Root knot of Vegetables, Ear cockle of wheat..

Laboratory Exercises:

1. Principles & working of tools, equipments and other requirements in the Mycology & Plant Pathology laboratory.
2. Micrometry and measurement of organisms.
3. Sterilization Processes viz. moist heat, dry heat, chemical and radiation.
4. Drawing of Camera Lucida diagrams and knowledge of computer based photomicrography and image processing
5. Preparation of different cultural media for cultivation of Fungi and Bacteria.
6. Monitoring and analysis of Aeromycoflora.
7. Isolation & identification of Phyllosphere mycoflora.
8. Demonstrate antifungal activities of different antibiotics and leaf, flower and root extract.
9. Study of toxicity of fungi in relation to seed germination, and seedling abnormality.
10. Cultivation of Mushrooms.
11. Demonstration on biodegradation of organic waste.
12. Isolation of Soil fungi by soil plate (War cup) and serial dilution (Walksman) method.
13. Isolation and identification of Rizosphere mycoflora.
14. Isolation of external and internal seed borne mycoflora by blotter and Agar Plate method. Cereals, pulses, oil seeds, fruit seeds.
15. Demonstration of Koch's Postulate.
16. Monographic study of locally available plant diseases caused by fungi (atleast 10).
17. Study of locally available crop plant diseases caused by Bacteria (Five)
18. Study of locally available plant diseases caused by viruses & Phytoplasma (Five)
19. Demonstration of morphological & physiological changes in disease plants.
20. Preparation and presentation of herbarium of pathological specimens available in the region (Atleast 20)
21. Field visit to different localities

Visit to Agriculture University, Plant Pathological research centers

Suggested Readings .

1. Agrios, G.N. (1980) Plant Pathology, academic Press, INC, New York.
2. Ainsworth, G.C. and A.S.Sussman (eds). The Fungi, An advance Treatise Vol.I, II, III & IV Academic Press, New York.
3. Alexopoulos, C.J. (1962). Introductory Mycology John Wiley Eastern Pvt.Ltd.
4. Alexopoulos, C.J. and Mims C.W. (1979). Introductory Mycology 3rd Edition, John Wiley and Sons, Inc. Wiley, New York.
5. Alexopoulos, C.J., Mims and Black well (1996) 4th ed. John Wiley and Sons, Inc. Wiley, New York
6. Aneja, K.R. (1993) Experimental in Microbiology, Plant Pathology & Tissue Culture, Wiswa Prakashan, New Delhi.
7. Bessey, E.A. (1950) Morphology and Taxonomy of Fungi. The Blakiston co. Philadelphia.
8. Bilgrami, K.S. and H.C.Dube (1985) A text Book of Modern Plant Pathology, Vikas Publication House, New Delhi.
9. Barnett, J.H. (1968) Fundamentals of Mycology. The English Language Book Society and Edward Arnold Publication, Limited.
10. Dube, R.C. and D.K.Maheshwari (1999) A.Text Book of microbiology, S.Chand & Co. Ltd.
11. Dube, R.C. and D.K.Maheshwari (2000) Practical Microbiology - S.Chand & Co. Ltd.
12. Gupta, V.K. and M.K.Behl (1994) Indian Plant Viruses and Mycoplasma Kalyani Publishers, 1/1, Rejinder Nagar, Ludhiana.
13. Jha, D.K. (1993) A Text Book of Seed Pathology, Vikas Publication House.
14. Mehrotra, R.S. (1989) Plant Pathology, Tata McGraw Hill.
15. Mehrotra, R.S. and K.R.Aneja (1998) An Introduction to Mycology, New Age Intermediate Press.
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17. Preece and Dickeson. Ecology of leaf surface microorganism Academic Press, New York.
18. Rangaswamy, G. and A.Mahadevan (1999) Diseases of Crop Plant in India, Prentice Hall of India.
19. Raychoudhari, S.P. and Nariani, T.K. (1977) Virus and Mycoplasma Diseases of Plant in India, Oxford and IBH Publication Co.
20. Schlegel, H.G. (1996) General Microbiology, 7th Edition, Cambridge University Press.

21. Snowdon, A.L. (1991) A colour Atlas of Post harvest diseases & disorders of fruits & vegetables Vol.I & II Wolfe Scientific, London.
22. Sunder Rajan, S. (2001) Tools and Techniques of Microbiology, Anmol Publ.New Delhi.
23. Thind, T.S. (1998) Diseases of field crops and their management, National Agricultural Technology, Information Centre, Ludhiana.
24. Vaidya, J.G. (1995) Biology of the fungi, Satyajeeet Prakashan, Pune.
25. Walker, J.G. (1952) Diseases of Vegetables Crops. McGraw Hill, New York.
26. Walker, J.C. (1968) Plant Pathology, McGraw Hill, New York.
27. Eggins, H.O.W. and Allsop (1975) The Filamentous Fungi Vol. I Industrial Mycology (Biodeterioration and Biodegradation by Fungi) Eds. J.E. Smith and D.R. Berry Edward Arnold, London.
28. Emmons, C. W., C. H. Bin ford, J.P. Utz and Know Chung (1977) Medical Mycology, Lea and Febigo, Philadelphia.
29. Holliday, P. Fungus disease of tropical plants (1980), Cambridge University Press, Cambridge.

On line Journals available on UGC -VSAT

SPECIALIZATION

Palaeobotany

M. Sc. Botany Syllabus

Semester IV

Course code/name: **Paper- XV : Palaeobotany (special) I**

MODULE – I:

Introduction to the science of Petrology- The earth zones, chemical composition of earth crust. The classification of rocks i.e. Endogenetic and Exogenetic (igneous, metamorphic and sedimentary) and their brief account. Glaciations, volcanic eruption and earthquake.

MODULE –II

Geological column and time scale. Physiography of India. Fossilisation, modes of preservation, preparation and age determination and techniques. Systematics, reconstruction and nomenclature. Life in Precambrian, greening of earth –speculation.

MODULE –III:

Study of Rhyniopsida (primitive vascular plants) Cooksonia, Steganotheca, Uskiella, Renalia, Horniophyton, Aglophyton, Zosterophylopsida (ancestors of microphyllous plants) Zosterophyllum, Sawadonia, Asteroxylon. Prelycopods and Lycopsidea-Hebaceous Lycopods of Devonian –Baragwanthia, Protolpidodendron and Miadnesia, Arborescent Lycopods of Carboniferous-study of Lepidodendrales members.

MODULE –IV:

Sphenopsida-Its origin and evolutionary consideration .Study of Hyeniales and Sphenophyllales .Horsetails and their relatives-Calamitales members. Filicopsida-Study of primitive ferns and their relatives- Cladoxylales, Stauropteridales, Zygopteridales. Filicales-classification and study of its members, Coenopteridales-Ankyropteris. Marratiales - Psaronius.

Suggested Laboratory and Field Exercises for Paper I

1. Stratigraphy Maps of the India and World
2. Geological Maps of India
3. Geological column and time scale.
4. Study of different rocks.
5. Different techniques to study fossils. (Ground sectioning, peel technique) Study different types of fossils
6. Study of plant fossils as per syllabus based on specimens and slides.
7. Study of Rhyniopsida (primitive vascular plants)
8. Arborescent Lycopods of Carboniferous-study of Lepidodendrales members
9. Sphenophyllales, Calamitales members.
10. Study of primitive ferns and their relatives Cladoxylales, Stauropteridales, Zygopteridales. Filicales-Coenopteridales-Ankyropteris. Marratiales - -Psaronius
11. Preparation of practical record.

M. Sc. Botany Syllabus

Semester IV

Course code/name: **Paper- XVI : Palaeobotany (special) II**

MODULE -I:

Gymnospermopsida-- Study of Aneurophytales and Archaeopteridales. Gymnosperm and early evolution (Archeosperma, Elkinsia, and Morentia) of seed habit stages in evolution. Study of Pteridosprmales-Lyginopteridaceae, Medullosaceae, Cycadeoidales-Cycadeoidaceae, Williamsoniaceae, Wielandiellaceae. and Fossil Cycads (Nilssonina, Baenia, Androstrobus).

MODULE -II:

Gymnosper- Caytoniales, Glossopteridales, Penntoxylales.fossil Cordaitales, Voltziales and phylogenetic consideration of all the orders.

MODULE -III:

Study of Deccan Intertrappean flora of India. Formation of Deccan traps and Intertraps, age and its floristic composition in relation to Pteridophytes, Gymnosperms and Angiosperms. Paleocene and Paleogeography of Deccan Intertraps.

MODULE - IV:

Paleopalynology-Important features of spores and pollen morphology, their role in stratigraphy and in exploration of coal and oil. Palaeopalynological studies, microfossils and its application. Paleocology and paleogeography. Indian Gonwana-Its stratigraphy and classification (Two fold and three fold). Index fossil.

Suggested Laboratory and Field Exercises for Paper II

1. Study different types of fossils
2. Study of plant fossils as per syllabus based on specimens and slides.
3. Gymnosperm- Caytoniales, Glossopteridales, Penntoxylales.fossil Cordaitales.
4. Lyginopteridaceae, Medullosaceae, Cycadeoidales-Cycadeoidaceae, Williamsoniaceae, Wielandiellaceae. and Fossil Cycads (Nilssonina, Baenia, Androstrobus).
5. Study of Deccan Intertrappean flora of India. Pteridophytes, Gymnosperms and Angiosperms-flowers and fruits.
6. Important features of spores and pollen morphology and technique to study them (Maceration)
7. Study of wood anatomy of fossils.
8. Exploration and excursion to different fossiliferous localities.
9. Preparation of practical record/submission of collection and tour report of excursion.

SPECIALIZATION

Palynology

M. Sc. Botany Syllabus
Semester IV

Course code/name: **Paper- XV : PALYNOLOGY (special) I**

MODULE -I: -

General aspects of Palynology: -Historical background, Definition , basic concepts, scope, inter-relationship with other branches of Botany, Applications, Indian work on Palynology, Palynological centres in India.

Microsporogenesis : Stamen initiation, anther differentiation- anther initiation, anther wall, Tapetum, structure and functions, its role in pollen development, Functions of callose wall, pollen/microspore and wall development, production and deposition of sporopollenin.

Pistil : Structure and function of stigma and style, stigma receptivity and its importance.

MODULE II: -

Pollination Biology -Origin of pollination biology/anthecology, Spore and pollen dispersal in lower plants and gymnosperms,

Pollination in angiosperms- types of pollination, floral adaptation to different pollinators (mode, style) flowers pollinated biotically (Hymenoptera, Diptera, Coleoptera, Lepidoptera, birds, bats) and abiotically (wind, water), pollination-plant interactions and evolution of breeding systems, special devices associated with pollinator attraction - pollen, nectar, Elaiophores, resin glands, osmophores, floral scent and perfume flowers.

Palaeopalynology: - Palynomorphs, their preservation in diverse lithic types, techniques involved in the recovery and concentration of spores and pollen from clays, shales, coals and lignites. Maceration techniques, Application of Palynology in relation to oil and coal exploration. Role of spores and pollen in stratigraphy, index spores.

MODULE III: -

Phylogeny of Pollen and spores, Systematic palynology-monocotyledoneae and dicotyledoneae, evolutionary trends among pollen grains based on palynotaxonomical works,

Palynology of spores / pollen- Algae, Fungi, Bryophytes, Pteridophytes and pollen types of Gymnosperms.

Pollen morphology of Angiosperms.: -

Introduction- Pollen units, polarity, symmetry, Shape, size, Apertures size, shape of the pollen grain, saccate pollen grain, sporoderm stratification, Apertures-NPC System of classification, Apertural types, Exine ornamentation, LO analysis

Pollen wall morphogenesis, evolutionary trends in exine structure, trends of evolution in apertural pattern,

Techniques for the preparation of pollen slides, Light and scanning electron microscopic studies of pollen, significance of SEM and TEM studies.

MODULE -IV:

Melittopalynology- pollen analysis of honey-methods, qualitative and quantitative, social behaviour of honey bees, floral fidelity, foraging behavior, geographical and floral origin of honey, its' chemical analysis, adulteration of honeys, physical characteristics of honey, honey quality standard, deterioration of honey, heavy metal contamination in honey, honey as environmental monitors, honey and allergy, unifloral and multifloral honey, pollen toxicity,

Applied Palynology with special reference to Agriculture and Horticulture - Bees as pollinators, role of apiaries in crop production. Bee keeping and enhanced honey production, recognition of areas suitable for honey production, use of honey in medicine, cosmetics, confectionary and other applications, pollen loads, analysis, Bee pollen, chemical composition, utility, and its role in curing various human ailments.

Semester IV

Course code/name: **Paper- XVI : Palynology (Special) II**

MODULE –I: Pollen physiology and biochemistry-

Pollen production,

Pollen viability, tests for pollen viability,

Pollen germination of pollen in *vivo* and in *vitro*, germination requirements, germination of 3-nucleated pollen grain, effect of pH and light, effects of hormones and other substances radiation effect, release of metabolites in germination and tube growth, Role of boron and calcium in pollen germination,

Chemical composition of pollen wall and pollen contents (amino acids, proteins, carbohydrates, lipids, vitamins, pectin, DNA, RNA, ascorbic acid, flavones, pigments etc.) in pollen and pollen tube at different steps in germination & their significance, pattern of pollen tube elongation,

Fine structure inside the tube, pollen culture movements of nuclei-and formation of callose plug, promotion and inhibition of pollen tube, elongation, pollen enzymes and isozymes,

MODULE –II: Pollen biotechnology and genetics

Pollen storage-Factors affecting viability in storage, freeze-drying of pollen, storage of pollen in organic solvents, causes of decreased viability in storage and pollen germination.

Pollen - pistil interaction - significance, self incompatibility (regulation of fertilization).Pollen allelopathy, chemotropism, Pollen herbarium,

Pollen biotechnology & crop production- Anther / pollen culture, production of haploids

Genetics of pollen: Genetic segregation of pollen, pollen sterility- genic and cytoplasmic male sterility, factors involved in male sterility. Male sterility through recombinant DNA technology.

Forensic palynology- Introduction, methodology, role in criminology, problems

MODULE –III: Aerobiology

Introduction, Historical background, applications of Aeropalynology Aeromycology Aerophycology. Importance in medical field, importance of aero mycological studies in various types of crop infection by spores, disease forecasting , aerobiological work in India and abroad.

Intramural and extramural studies, different devices to collect spores, pollen grains such as kite, balloons, trap air strips and slides, volumetric samplers, culturing techniques, analysis of data and their processing, seasonal changes of air-spora

Indoor environments, Sick buildings & hazards, occupational environment and immunology,Outdoor airspora, characteristics, identification,

MODULE –IV: Airborne allergens

Introduction, allergens and their types, Impact of airborne materials on human system, Lung as particulate sampler,

Source, causes, symptoms of Pollen allergy, fungal spore allergy, dust mite allergy, algal allergy other allergies, Prevention and cure, isolation & culturing of spores, mites, algae.

antibodies to human immunoglobulin, types, and significance in diagnosis of allergy, diagnosing allergic diseases based on total and specific IgE determinations, radio immunoassay, (RAST, PRIST, ECP-immunoassay technique), ELISA (competitive, Double-antibody sandwich, indirect ELISA), Western blotting, allergen standardization, Testing and treatment, pollinosis, nasobroncheal allergy, Immunotherapy and prevention of allergy, pollen calendar and daily census of airborne pollen, circadian periodicities of pollen, Correlation between aerobiological, clinical and meteorological data.

LIST OF PRACTICALS: -

Section A. Basic aspects / Pollen Morphology

1. To study structure of stamen
2. Study of permanent slides of microsporogenesis
3. Field study on different pollination mechanism
4. To study structure of pistil
5. Preparation of glycerin jelly
6. Preparation of pollen- Acetolysis technique
7. Preparation of pollen – Wodehouse technique.
8. Study of pollen types using acetolysed and non-acetolysed pollen. Pollen morphology polarity, symmetry, shape, size, sporoderm stratification aperture NPC (To study the pollen types from at least 30 different species, Angiosperms preparation of permanent slides.)
9. Preparation and palynological description in technical language (at least 10 species of Angiosperms).
10. Interpretation of selected electron micrographs (SEM, TEM) of pollen.
11. Preparation, description and identification of spores of Algae, Fungi, Bryophytes, Pteridophytes and pollen types of Gymnosperms.

Section B. Aeropalynology/Melittopalynology/Palaeopalynology

12. Use of pollen traps to study local air-spora.
13. Analysis of aerospora slides.
14. Preparation of reference slides by different techniques, culture method (culture of fungi/Algae)
15. Preparation of slides honey samples
16. Analysis of honey samples for qualitative and quantitative study of pollen contents.
17. Estimation of pollen load from bee hive or bees/ pollinator
18. Analysis of coal samples for microfossils with special reference to pollen and spores.
19. Preparation of allergenic extract of pollen.

Section C Pollen Physiology/ecology/biochemistry/ecology. (Expt. No.29 is compulsory)

20. To study pollen production and pollen viability of the given flowers.
21. To study percentage of pollen germination & rate of pollen tube growth.
22. To study different techniques of pollen storage
23. Effect of temperature and relative humidity on viability of stored pollen
24. Effect on Boron and Calcium on pollen germination and tube growth.
25. Semi-vivo technique to study pollen germination and pollen tube growth.
26. Multiple staining for localizing pollen tubes in the pistil
27. To study pollen germination and pollen tube growth in the pistil by employing aniline-blue fluorescence method
28. Cytochemical localization of esterase on stigma surfaces
29. Cytochemical analysis of pollen and pollen tube for various metabolites like proteins, amino acids, carbohydrates, starch, ascorbic acid, DNA, RNA, lipids, lignin, pectin, cellulose, etc (at least five metabolites)
30. Study of pollen contents by paper chromatography/TLC.
31. Colorimetric estimation of proteins/carbohydrates of pollen grains
32. To separate pollen proteins by SDS-PAGE electrophoresis
33. Enzyme bioassay in pollen grains.

Suggested Readings .

1. Afzelius, B.M. 1956 Electron-microscope investigation into exine stratification *Grana Palynologica* (N.S.) 1:2,
2. Agashe S. N. – Paleobotany (1997) – Plants of the past their evolution paleoenvironment and applications in exploration of Fossil.
3. Agashe S. N. – Palynology and its Applications – Oxford and IBH Publishing Co. Pvt. Ltd. New Delhi.
4. Alexander M.P. (1969). Differential staining of aborted and non-aborted pollen *Stain Technol* 44:117-122.
5. Alexander, M.P. (1987). A method for staining pollen tubes in pistil. *Stain Technol* 62, 107-112.
6. Alexander, M.P., Ganeshan S. (1990). An improved cellophane method for *in vitro* germination of recalcitrant pollen. *Stain Technol* 64:225-227. *Archaeology, Rev. Palaeobot. Palynol* 21:171-185,
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10. Bhattacharya K., Majumdar M. and Gupta Bhattacharya S. (2006). A text book of Palynology. New Central Book Agency(P) Ltd., Kolkata

11. Bhojwani, S .S. and S.P. Bhatnagar. 1978. The Embryology of Angiosperms. Vikas Publishing House, New Delhi,
12. Bir Bahadur 1998. Nectary biology. Datt sons publications, Nagpur
Bombay,
13. Brooks. J. and G. Sha'w. 1978. Sporopollenin: A review of its chemistry, palaeochemistry and Geochemistry. *Grana. 17(2) : 91-98.*
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15. Chowdhary, J.B. and T.M. Varghese. 1968. Pollen sterility in crop plants- A review *Palyn. Bull.IV (2).*
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19. Dafni Amots, Hesser Michel, Paeini Ettore – Pollen and Pollination- Springer Wien New York
20. Davis. P.H. and V.H. Heywood. 1963. Principles of Angiosperm Taxonomy. Oliver and Boyd, London,
21. Dumas C, Knox R.B. (1983). Callose and determination of pistil viability and incompatibility. *Theor Appl. Genet* 67: 1 -10.
22. Echlin, P. Pollen. 1968. *Scientific American 218(4),*
23. El-Gazzar and M.K. Hamza. 1973. Morphology of the twin Pollinia of Asclepiadaceae. *Pollen et spores XV (3-4)*
24. Erdtman, G, (1956) "Lo-analysis" and "Welcker's rule". *Sven Bot. Tidskr.* 50:1-7.
25. Erdtman, G. 1945. Pollen Morphology and Plant Taxonomy IV Labiatae, Verbenaceae, Avicenniaceae. *Svensk Botanisk Tidskrift. 39(3),*
26. Erdtman, G. (1966). Pollen morphology and plant taxonomy angiosperms hafner. New York.
27. Erdtman, G. (1969). Handbook of Palynology. Hafner, New York
28. Erdtman, G. 1943. An Introduction to Pollen Analysis. Chronica Botanica Co., Waltham, Mass. pp. 239,
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39. Heslop-Harrison, J. (1987). Pollen germination and pollen tube growth. *Int. Rev. Cytol.* 107:1-78.
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Practical Schedule :

Semester III

PRACTICAL V

| | | |
|---|--------------|-----------|
| Time : 6 Hours | Full marks : | 80 |
| Q. 1 To perform the given Ecological exercise - [A] | | 15 |
| Q. 2 Soil analysis/Ecological adaptation - [B] | | 10 |
| Q. 3 One experiment from paper X - [C] | | 15 |
| Q. 4 One experiment from paper X - [D] | | 10 |
| Q. 5 Spotting: [E] (Paper IX), [F] (Paper IX), [G] (Paper X), [H] (Paper X) | | 20 |
| Q. 6 Viva-voce | | 5 |
| Q. 7 Practical Record | | 5 |

Semester III

PRACTICAL VI

| | | |
|--|--------------|-----------|
| Time : 6 Hours | Full marks : | 80 |
| Q. 1 One experiment from paper XI – [A] | | 15 |
| Q.2 One experiment from paper XI – [B] | | 10 |
| Q.3 To describe the given plant in technical language with floral formula and floral diagram [C] | | 15 |
| Q. 4 To prepare the generic/family key [D] | | 10 |
| Q. 5 To identify the species of the given plant using the standard flora [E] | | 5 |
| Q. 6 Spotting: [F] (Plant biotechnology), [G] (Plant biotechnology), [H] (Angiosperms) | | 15 |
| Q. 7 Viva-voce | | 5 |
| Q. 8 Practical Record and tour report | | 5 |

Semester IV

PRACTICAL VII (on special paper)

| | | |
|------|---|-----------|
| | Full marks : | 80 |
| Q. 1 | Experiment from paper - I | 10 |
| Q. 2 | Experiment from paper - II | 10 |
| Q. 3 | Experiment from paper - I | 10 |
| Q. 4 | Experiment from paper - II | 10 |
| Q. 5 | Spotting: E (paper - I), F (paper - I), G (paper -II), H (paper - II) | 20 |
| Q. 6 | Viva-voce | 10 |
| Q. 7 | Practical Record | 10 |

Semester IV

PRACTICAL VIII

Full marks : **80**

PROJECT
