M.Sc. Botany (NEP-2020)

Semester III

Mandatory Paper: DSC: MBO3T08: Plant Development & Reproduction

Objectives:

- To understand the different forms and organization of Angiosperms.
- The understand the internal architecture of the plant, cellular composition and growth
- To study the pathways of and the underlying genetic and molecular factors involved in plant development.
- To study reproduction in Angiosperms.

Outcomes

- The student discovers the variation in Angiosperms at morphological and anatomical level.
- The student understands the mechanisms leading to development of the plant organ.
- The student realizes the interplay of genetic and environmental cues in plant development.
- The student admires the alternatives to sexual reproduction and is able to put them for practical application.
- The student understands the role of cell death in plant development.

Module I:

Plant Development

- Introduction to plant developmental biology; Patterns of growth; Seed germination; Seedling growth, tropisms (gravitropism, phototropism, thigmotropism); photo morphogenesis of the seedling, hypocotyl and internode growth, hormonal control of seedling growth, gene expression during seedling growth.
- Shoot development: Organization of the shoot apex, shoot apical meristem (SAM), tissue differentiation in the shoot, histological differentiation (transformation of meristem to permanent tissue); Meristematic tissue- Primordial or promeristem, primary meristem, secondary meristem, apical meristem, intercalary meristem, lateral meristem, theories of

structural development and differentiation (apical cell theory, histogen theory and tunica corpus theory).

- The primary body: The stem anatomy–Cucurbita, Calotropis, Triticum, Asparagus.
- The Secondary growth in stem: Example- Sunflower (Origin and activity of vascular cambium), secondary xylem, secondary phloem.
- Origin of phellogen or cork cambium, cork and bark (periderm).
- Anomalous secondary growth: Adaptive anomaly-, Leptadaenia, Aristolochia, Bignonia unguis-cati, Casuarina; Non-adaptive anomaly- Boerhaavia, Amaranthus, Chenopodium

Module II:

Plant development cont. …….

- Root-stem transition; Nodal anatomy.
- The Root anatomy– Maize, Vanda, Pneumatophore.
- Secondary growth in Dicot Root: Example- Sunflower.
- Leaf growth and differentiation: Leaf determination and development, determination of leaf primordia, evolution of leaf form, heteroblasty, heterophylly, differentiation of leaf cells (epidermis, mesophyll), senescence and abscission of leaves.
- Root development: Root apical meristem (RAM), organization of root apex, differentiation of the root, root hair formation, lateral root initiation, root-microbe interaction (mycorrhiza).
- Anatomy of Dicot and Monocot leaf: Nerium and Maize leaf.
- Floral anatomy; Morphological nature of the wall of inferior ovary (The appendicular theory and Receptacular theory)

Module III:

Reproduction

- Floral evocation and development of floral meristem; photoperiodic control of flowering; Molecular control of floral evocation; Formation of floral organs; Homeotic mutants (Arabidopsis and Antirrhinum).
- Microsporogenesis and formation of male gametophyte: Anther differentiation; Anther structure- Anther wall development, tapetum (ultrastructure), sporogenous cells, microspore mother cells, meiosis, cytokinesis, callose and its role, microspore tetrad, structure of mature pollen grain; Pollen development and maturation- Vegetative Cell, generative cell, gene expression during pollen development, formation of male germ unit, sperm dimorphism, pollen sterility and abortion.

- Megasporogenesis and formation of female gametophyte: Structure of carpel, ovule- Types, structure, development, integument, micropyle, obturator, endothelium, hypostase, epistase, nucellus; Megasporogenesis- Megaspore mother cell, megaspore tetrad, megagametogenesis, organization of embryo sac, types of embryo sac, details of monosporic or Polygonum type of embryo sac, molecular structure of embryo sac cells.

Module IV:

Reproduction cont. ……

- Fertilization: Pollen-pistil interaction, pollen germination, structure and growth of the pollen tube, guidance, fertilization; Self-incompatibility; Methods to overcome self-incompatibility.
- Embryo development; Endosperm development- type, ultrastructure, nuclear cytology, storage proteins; Apomixis- definition, diplospory and apospory, factors involved; Fruit development; Seed dormancy- types, importance, overcoming seed dormancy; Bud dormancy.
- Senescence and PCD (Programmed cell death): Basic concepts, metabolic changes, influence of hormones and environmental factors.

(The above-mentioned topics should be taught in the light of the recent developments in the field)

Suggested readings

Bewley, J.D. and Black, M. 1994 Seed: Physiology of development and germination, 2nd ed. New York. Plenum press.

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

Clarke, S.E. 1997. Organ formation at the vegetative shoot meristem. Plant cell 9:1067 – 1076.

Eames. A.J. and Mac-Daniels L.H 1953 An Introduction to plant anatomy. Mc Graw Hill Book CO. London New York.

Esau Katherine 2002 Anatomy of Seed Plants, John Wiley and Sons (Asia) Pvt. Ltd.

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

Fahn, A. 1982 Plant Anatomy, (3rd edition). Pergamon Press, Oxford.

Fosket, D.E. 1994 Plant Growth and Development A molecular Approach. Academic Press, San Diego.

Goldbeg, R.B. Beals. T.P and sanders, P.M 1993, Anther development: Basic principles and practical applications plant cell 5: 1217 – 1229

Greyson, R.I 1994 The development of flowers. Oxford University Press.

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

Johri, B.M (Ed.) 1984 Embryology of Angiosperms. Springer-Verlag. New York.

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. Unnin Hyman, London. Maheshwari, P 1950 An Introduction to the Embryology of Angiosperms. MC – Graw – Hill, London. New York.

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

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

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

33.

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

Richard Crang, Sheila Lyons Sobaski, Robert Wise, 2018 Plant Anatomy, Springer

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

Shivana, K.R. and Johri, B.M. 1985 The Angiosperm Pollen: Structure and Function. Wiley Eastern Ltd., New York.

Shivana, K.R. and Rangaswamy, N.S. 1992 Pollen Biology: A Laboratory Manual. Springer-Verlag, Berlin.

Steeves, T.A. and Sussex, I.M. 1989 Patterns in Plant Development (2nd edition). Cambridge University Press, Cambridge.

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

Recent issues of the relevant ‘Annual Reviews’ should also be consulted.

Mandatory Paper: DSC: MBO3T09: ANGIOSPERMS – I

Objectives:

- To study the typical structure and modifications in the organs of angiosperm plants.
- To study the development of the systems of plant classification from antiquity to present.
- To study the concepts of plant classification and the evidences used to organize the plant groups.

Outcomes

- Comprehend the basic concepts and use scientific terminology accurately.
- Know the relationship and evolutionary processes and patterns in the major plant groups.
- Handle, analyze and identify plant materials in the laboratory, herbarium collections and in the field.
- through effective oral and written communication and use dichotomous keys in floristic manual.
- The student explores various characters, which can be used to classify the plants.

Module I:

- **Plant Structure:** Plant life form (therophyte, geophytes, epiphyte, halophyte, stem and leaf succulents, xerophytes); Plant life forms denoting nutritional physiology– saprophyte, mycotrophs (mycoheterotrophs), parasites, hemi- and obligate-hemiparasites, facultative hemiparasites. Root types; Stem types: Stem habit (acaulescent, caulescent, cespitose, prostrate, repent, arborescent, suffrutescent, decumbent), Stem branching pattern (hepaxanthic, pleonanthic, determinate, indeterminate, pseudomonopodial, syllepsis, prolepsis), twigs, trunks, and buds. Leaf: Structure, kind, venation, leaf margin, leaf apex, ptyxis, vernation, indumentum, domatia and glands, General Terminology- Colour, number, merosity, texture, fusion, shape, apex, margin, disposition, arrangement, orientation, posture, surface, epidermal excrescence (outgrowths) or indumentum or trichomes. Refer Plant systematics by Michael G. Simpson 3ed. (2019). Note: Plant structure, leaf, general terminology for mainly practical purpose.
- **Floral Morphology:** Floral organization; Receptacle (thalamus or torus); Perianth (diversity, aestivation, functions); Androecium- evolutionary considerations, transformation of fertile stamens to staminodes, fusion of stamens, primitive stamens, anther, filament,

dehiscence of anther; Gynoecium (pistil)- carpel, ovary, style, stigma, apocarpous and syncarpous gynoecia, placentation (evolutionary tendencies).

- **Floral Biology:** Pollination mechanisms and Vectors (mode of pollinations), floral adaptations, special differentiations associated with pollinator attractions.

Module II:

- **Angiosperm Taxonomy (Systematics):** Definition, objectives, scope; Phases of development in plant taxonomy: Phase I - Theophrastus, Dioscorides, Phase II - The herbalist – Otto Brunfels, Valerius Cordus, Phase III - Early taxonomists-Caesalpino, Tournefort, Phase IV - Concept of Linnean system of classification, merits and demerits; Conceptual basis of classification of flowering plants of following systems: Bentham and Hookers system, Engler and Prantl's system, Hutchinson's system, Takhtajan system and Cronquists system. Modern approach in plant classification.
- Molecular systematics; DNA sequence data; Establishment of Angiosperm phylogeny group (APG) - Introduction (outlines) to APG-I, APG-II and APG-III. Details about APG-IV system (2016) with emphasis on major Clades.

Module III:

- Evolutionary concepts Population and environment; Origin of Intra-population variations; Taxonomic Structure; Concept of taxa– concept of species, concept of genus and family, isolation mechanisms.
- Taxonomic character Heterobathmy; Concept of character, character variations and their taxonomic implications; Analytic versus synthetic character; qualitative versus quantitative characters.
- Taxometrics Numerical taxonomy and Cladistics- Principles, methodology, merits and demerits.
- Taxonomic tools Herbarium and Botanical gardens: Conservation of plants; Important herbaria and botanical gardens of world and India; Websites for taxonomic literature.

Module IV:

Taxonomic evidence

- **Morphology:** Habit, leaf, floral morphology, inflorescence, fruit, seed.

- **Anatomy:** Nodal anatomy, leaf anatomy, secretory structures, arrangement of xylem and phloem in stem, root, floral anatomy, inferior ovary: interpretations– appendicular versus axial theory.
- **Embryology:** Anther development, ovules, female gametophyte, embryo, endosperm seed.
- **Cytology:** Chromosome number and structure.
- **Palynology:** Pollen structure, exine, exine ornamentations, intine.
- **Phytochemistry:** Ergastic materials; Secondary plant compounds- alkaloids, betalains, anthocyanins, glucosinolates, terpenoids.
- **Biochemistry:** Amino acid sequence, systematic serology, electrophoresis.

(The above-mentioned topics should be taught in the light of the recent developments in the field)

Suggested readings

A.D. and Wibins, A.D. 1971 Variation and adaptation in Plant species Hickman and Co. New York.

A.R.G. Gautner Verlag K.G. Mitra, J.N 1974 An introduction to systematic Botany and ecology, The world press pvt. Ltd. Calcutta Murrell, 2010 Vascular Plant Taxonomy, 6th edition, Kendall/Hunt Publishing co., Dubuque, Iowa.

Annals of the Missouri Botanical garden 85:531-553.

APG II 2003 An update of the Angiosperm phylogeny group classification for the orders and families of flowering plants.

APG II Botanical Journ of Linnean Society 141: 399-436 APG III 2009 An update of the Angiosperm Phylogeny groups classification for the orders and families of flowering plants.

APG III Botanical Journal of the Linnean society 161: 105- 121. APG IV 2016 An update of the Angiosperm Phylogeny group classification for the orders and families of flowering plants.

APG IV Botanical Journal of the Linnean society 181, 1- 20.

Bell, A.D. 2008 Plant form: An illustrated guide to flowering plant Morphology with line drawing by Alan Bryam Timber Press, Portland, Oregen. Benson, L. 1902 Plant Taxonomy, Ronald Press, New York.

Bishen Singh Mahendrapal Singh. Kitching, I.J. 1998 Cladislics. The theory and practice of parsimony analysis, 2nd ed. Oxford Uni. Press. Oxferd.

Briggs David 2009 Plant microevolution and Conservation in Human-influenced Ecosystems. Cambridge University Press.

Cantino, P.D. and K.de Quiroz (2007) International code of phylogenetic nomenclature. Version 4b. http://www.ohio.edu/phylocode.

Crane, PR, E.M Friis and K. Pedersen 1995 The Origin and early diversification of Angiosperms. Nature 374:27

Crept, W.L 1998 The abominable mystery, Science 282:1653-1654.

Cronquist, A. 1981 An Integrated system of classification of flowering plants Columbia University Press, New York. Cronquist, A. 1988 The Evolution and Classification of Flowering Plants (2nd ed.) Allen Press, U.S.A.

Dahlgren, R.M.T. Clifford, H.T & Yeo, P.F. 1985 The Families of Monocotyledons. Springer Verlag.

Davis, P.H. & Heywood, V.H. 1991 Principles of Angiosperm Taxonomy.

Douglas, E & Soltis et al. 2005 Phylogeny and Evolution of Angiosperms. Sinauer Associates Inc.

Doyle, J.A 2006 Seed ferns and the origin of Angiosperms. Journal of Torrey Botanical Society 133:169-209

Erdtman, G 1952 Pollen Morphology and Plant Taxonomy, Angiosperms, Almquist and wicksell, Stolkholm.

Esau, K 1965 Plant Anatomy, 2nd Ed. John Wiley and Sons, New York.

Friedman, W.E. and 2009 Reconstructing the ancestral female gametophyte of angiosperms Insights from Amborella and other ancient lineages of flowering Plants. American Journal of Botany 96 : 129 -143.

Friis, E.M., J.A. Doyle, P.K. Endress and Q Leng 2003 Archaefructus: Angiosperm precursor or specialised early angiosperm? Trends in Plant Science 8:369 – 373

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

Griffith, C (1996) Onwards Dictionary of Botanical Epithets. http:www.winternet.com/-chuckg/dictionary.html

Harris J.G. & M.W. Harris. 2007 Plant Identification Terminology. Spring Lake Publishing.

Harrison, H.J 1971 New concept in flowering plant Taxonomy. Hickman educational books Ltd. London.

Heslop-Harrison, J 1967 Plant Taxonomy. English Language Book Sco. And Edward Arnold Pub. Ltd, UK.

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

Hutchnson, J 1973 The Families of Flowering plants. Oxford. 3rd. Edition Clarendon Press oxford.

International plant name index A list of current plant names from three sources: the Index Kewensis (IK), the Gradcard Index (GCI) and the Australian plant names Index (APNI). http://www.ipni.org Recent issues of the relevant 'Annual Reviews' should also be consulted.

Janick, J. et al. 2002 International Code of Nomenclature of Cultivated Plants. International Society for Horticulture Science.

Johri, B.M 1963 Embryology and Taxonomy in P. Maheshwari (Ed) Recent advances in the Embryology of Angiosperms. Int. Soc. Pl. Morp. Uni. Delhi. New Delhi PP 395-444. Jones.

Judd W.S., Campbell, C.S., Kellogg, E.A., Stevens P.F. and M.J. Donoghue 2008 Plant Systematics: A phylogenetic Approach. Sunderland, Massachusetts, USA.

Judith, E.W. 2002 Describing Plant Species.

Kitching, I.J. et al. 1998 Cladistics – the theory and practice of Parsimony Analysis. Oxford University Press.

Lawrence George H.M. 1951 Taxonomy of Vascular Plants, Oxford and IBH Publ. Co. Pvt. Ltd. New Delhi.

Leadlay E. and S. Jury (ed.) 2006 Taxonomy and Plant conservation. Cambridge University Press. Manilal K.S. 1980 Botany and History of Hortus Malabaricus. Oxford & IBH Pub. Co. Manilal, K.S. And M.S.

Mc Neill, J. et al. 2006 International Code of Botanical Nomenclature (ICBN) (Vienna Code).

Mich Zomlefer, W.B 1994 Guide to flowering plant families university of North Carolina Press, chapel Hill. Web Sites

Moritz and B.K. Mable (1996) Molecular Systmatics, 2nd ed. Sinauer, Sundarland, Massachusetts.

Muktesh Kumar [ed.] 1998 A Handbook of Taxonomic Training. DST, New Delhi.

Naik, V.N. 1984 Taxonomy of Angiosperms. Tata McGraw-Hill Publication Com. Ltd. New Delhi. Nair, P.K.K 1980 Glimpses in plant Research-V Modern Trends in plant Taxonomy, Vikas publisher, New Delhi.

Nair, P.K.K. 1970 Pollen Morphology of Angiosperms, Vikas Publishers, New Delhi. Naqshi, A.R. 1993 An Introduction to Botanical Nomenclature. Scientific Publishers.

Nordentam, B., El. Gazalu. And Kassas. M 2000 Polunin, N. 1960 An Introduction to plant geography and some related science, Long mans London.

Quick, Donald, L.J. 1993 Principles and Techniques of Contemporary Taxonomy. Blakie Academic & Professional, London.

Radford, E.A. 1986 Fundamentals of Plant Systematics. Harper & Row Publishers.

Retallack, G. and D.L. Dilcher. 1981 Arguments for a glossopteris ancestry of angiosperms Paleobiology 7:5A-67.

Shivarajan, V. V. 1984 Introduction to the Principles of Plant Taxonomy Oxford and IBH Publishing Co. Ltd. New Delhi Simpson M.G 2010 Plant systematic (Second Edition) Elsevier.

Singh, H. 2010 Plant Systematics. An integrated approach, 3rd edition. Science Publishers, Enfield. N.H.

Sokal, R.R and P.H.A. Sneath 1963 Principles of Numerical Taxonomy, W.H. Freeman, San Francisco α London.

Solbrig, O.T. 1979 Principles and methods of plant Systematics. The Macmillan Publication Inc., USA. Soltis, D.E. P.S.

Soltis and J.J Doyle (eds.) Molecular systematic of Plants. DNA sequencing, Kluwer, Academic, Boston.

Stace, C.A. 1989 Plant Taxonomy and Biosystematics chapman and Hall Inc. New York.

Stebbins, G.L. 1974 Flowering Plants-evolution Above species Level. Edvard Arnold Ltd, London.

Stevens, P. F. (2001) Angiosperm phylogeny website. http://www.mobot.org/MOBOT/research/APweb. (An excellent graphical representation and update of Angiosperm phylogeny group classification, cladograms, family characteristics, references, and apomorphies) iPlants – The world's Plant outline http://www.iplants.org (An attempt to provide an index of the world's plant species, administered by the Royal Botanic Gardens, Kew, the Missouri Botanical Garden, and the New York Botanic Garden.

Sun, G, Q. Ji, D.L. Dilcher, S. Zheng, K.C. Nixon and X. Wang,2002 Archaefructaceae, a new basal angiosperm family Science 296:899-904.

Takhtajan, A.L. 1997 Diversity and classification of Flowering Plants. Columbia University Press, New York.

Wallace, R.S and A.C Gibson 2002 Evolution and systematics In Nobel, P.S. (ed.) cacti Biology and uses pp. 1-21 university of California press, Berkeley.

Woodland, D.W. 1991 Contemporary Plant Systematics, Pentice Hall, New Jersery. Woodland, DW 2009 Contemporary Plant Systematics, 4th edition Andrews university Press, Berrien Springs.

Mandatory Paper: DSC: MBO3T10: Plant Ecology and Conservation Biology

Objectives:

- To study the role of biotic and abiotic factors in the development of vegetation.
- To study the flow of energy and elements in the ecosystem.
- To study the factors involved in stabilizing the ecosystem.
- To study the concept of biodiversity and the ways to conserve the biodiversity.
- To understand concepts of carbon sequestration and ecological footprint

Outcomes

- The student acknowledges the role of each factor involved in the development and maintenance of the ecosystem.
- The student realizes the ways leading to sustainable development.
- The student is skilled with the techniques to study the ecosystem and the methods to conserve the biodiversity.
- The student will comprehend the process of carbon sequestration as greenhouse mitigation policy

Module I:

- **Vegetation organization:** Types of ecology: Autecology and Synecology; Concept of community; Analysis of communities (analytical and synthetic characters): interspecific associations; Concept of ecological niche.
- **Vegetation development:** Temporal changes (cyclic); Ecological succession- types, mechanism, and dynamics, examples (Hydrosere, Xerosere, Lithosere), models of ecological succession (relay floristics and initial floristic composition, facilitation, tolerance and inhibition models, laboratory models); Climax concept.

Module II:

- **Ecosystem organization:** Structure and functions; Primary productivity (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); Soil profile, Global biogeochemical cycles of C, N, O, P and S; Hydrological cycle; Nutrient budget in forest and aquatic ecosystem.

Module III:

- **Ecosystem stability:** Concept (resistance and resilience); Ecological perturbations (natural and anthropogenic) and their impact on plants and ecosystems; Ecology of plant invasion; Environmental impact assessment; Ecosystem restoration.
- **Ecological management:** Concepts; Sustainable development; Sustainability indicators.

Module IV:

Biodiversity conservation:

- Biodiversity - Concept, type, threats, measurements; Biodiversity hot spots.
- IUCN- General account, categories, commissions, role in conservation; Red Data Book. Protected areas - Sanctuaries, National parks, Biosphere reserves. Wetlands and Mangroves. Coral Reefs- Types, importance, artificial reefs, conservation measures. Botanical gardens, Seed Banks, In-vitro repositories, Cryobanks.
- Carbon sequestration: definition, concept, and role in climate mitigation

(The above-mentioned topics should be taught in the light of the recent developments in the field)

Suggested readings

Ambasht RS 1968. Freshwater ecosystem-Manual of Ecology 123-137 (See Misra KC et al. 1968)

Ambasht RS 1966 Conservation Ecology, Abs Proc School on Plant Ecol (Full paper in press Oxford and IBH Calcutta).

Ambasht RS 1995 A text book of plant ecology Student and co. Varanasi-5 Anderson JM Ecology for environmental sciences: biosphere ecosystems and man.

Billings WB 1964 Plants and the ecosystem Macmillan & co, London.

Clements FE 1916 Plant succession, An analysis of the development of vegetation. Carnegie Institute of Washington.

Cragg JB 1968 The theory and practice of conservation, IUCN Publ, New Series No. 12, 25-35.

Dash MC 1993 Fundamentals of Ecology WB Saunders and co. Philadelphia USA. Deangelis DL Energy flow, nutrient cycling and ecosystem resilience. Ecology 56, 23843.

Dwivedi Rama Shankar 1968. The decomposer system manual of ecology (See Misra KC et al. 1970)

Frankel OH, Soule ME, 1981 Conservation and Evolution, Cambridge Univ Press.Grace J 1983 Plant atmosphere relationships. Champman & Hall.

Greig Smith P 1983 Quantitative plant ecology, Univ California Press, California.Hutchings MJ (ed) 1988 Plant population biology, Blackwell.

Hutchinson GE 1978, An introduction to population ecology. Yale Univ. Press.Kochhar PL 1986 Plant Ecology Ratan prakashan, Mandi, Agra.

Krebs GJ 1972 Ecology Harper and Row Publ, New York.

Kumar HD 1994 Modern concepts of ecology. Vikas publishing house pvt ltd, New Delhi.May RM (ed) 1981 Theoretical Ecology, Blackwell.

Odum EP 1963 Ecology Holt Reinhart and Winston Inc

Odum EP 1983Basic Ecology, Saunders Publ Philadelphia.Philadelphia.

Reynolds CS 1984 The ecology of phytoplankton, Cambridge Silverton JW 1982 Univ Press Introduction to plant population ecology, Longman.

Southwick CH 1983 (ed) Global Ecology Sinauer.

Subrahmanyam NS and Sambamurthy AVSS 2006 Ecology 2 Ed Narosa Publishing House Pvt. Ltd.

Whittaker RH 1975 Communities and Ecosystems (2nded) MacMillan, New York.

Recent issues of the relevant 'Annual Reviews' should also be consulted.

Websites

https://epgp.inflibnet.ac.in/epgpdata/uploads/epgp_content/S000033SO/P000296/M009128/ET/149605367912ClimateChangeandCarbonFootprint.pdf

http://www.carbonfootprint.com

http://www.footprintnetwork.org/en/index.php/GFN/page/carbon footprint

http://www.eoearth.org/article/Carbon_footprint

Brian I McPherson; E T Sundquist, 2009. A book on Carbon sequestration and its role in global carbon cycle, Washington, DC: American Geophysical Union; published under the aegis of the AGU Books Board.

http://envfor.nic.in/cc/edm/publications.htm

Elective Paper: DSE: MBO3T11: Molecular biology and Plant Biotechnology- I

Objectives:

- To give the student in-depth information on the tools and techniques used for isolation and cloning of a gene.
- To study the techniques used to express the trans-gene and manipulate the gene to produce desired product.
- To study the methods used to characterize the nucleotide and protein sequences.

Outcomes

- The student is able to isolate, clone, express & characterize the desired gene in the host.
- The student is informed about the techniques to manipulate the gene and chromosome as desired.
- The student compares the nucleotide and protein sequences and deduces their structural and functional features.
- The student deduces the phylogenetic relationship between organisms.

Module I:

- **Transformation:** Definition (in context with rDNA technology); properties of an ideal host (in context with rDNA technology); Techniques: Calcium chloride method, using virions, electroporation; Selection of the recombinant clones.
- **DNA library:** gDNA library: Introduction, partial digests, choice of vectors, size of the library, constructionand evaluation of the library, growing and storing libraries; cDNA library: Introduction, isolation of mRNA, cDNA synthesis, cloning the cDNA; Types of DNA libraries: Random, arrayed and ordered.
- **Screening the DNA library:** Hybridization: Introduction, labelling probes, hybridization procedure, screening procedure, probe selection and generation; Screening the expression libraries with antibodies; Advanced screening: Subcloning, characterisation (restriction digestion & electrophoresis, Southern blotand PCR & sequence analysis).

MODULE II:

- **Polymerase chain reaction:** The basic technique; Primer design; Analysis and cloning of PCR products; Variants of PCR (Inverse, Anchored, Overlap extension, Asymmetric,

Thermal cycle sequencing, Nested, Touchdown, Hotstart, ARMS, Long-range, Reverse-transcription, RACE, Realtime PCR); Applications of PCR in molecular biology; Advantages and limitations.

- **Site-directed mutagenesis:** Introduction; Advantages and Limitations; Candidate properties of enzymes to alter; Procedure: Direct mutagenesis (Overlap extension PCR, Inverse PCR and mutant proteins withunusual amino acids), Random mutagenesis (Error-prone PCR, random insertion/deletion, degenerate primers and DNA shuffling).
- **Protein engineering:** Need to engineer proteins; Strategies: Increasing protein stability, modifying protein specificity, modifying cofactor dependence and decreasing protease sensitivity.
- **Chromosome engineering:** Introduction; Cre/loxP mechanism: Technique, example of engineering the baker's yeast; CRISPR/Cas mechanism: Limitations of Cre/loxP mechanism, advantage of CRISPR/Cas mechanism, the technique and CRISPR/Cas components; Targeted chromosome arrangement in plants; Applications of chromosome engineering.

MODULE III:

- ***In vitro* transcription:** Introduction; a typical in vitro transcription reaction; in vitro transcription systems: Run-off assay, transcription-complex assay, S1 mapping and RNase protection assay, G-free sequence system and primer extension assay.
- ***In vitro* translation:** Introduction to cell-free translation system (CFPS); Advantages of CFPS; Translation systems: Rabbit reticulocyte lysate, wheat germ extract, E. coli cell-free system; Linked transcription: translation system; Coupled transcription: translation system; Applications of CFPS.
- **Sequence alignment:** Need for sequence alignment; Gaps in alignment; Gap penalty; Methods to choose best alignment: Similarity and distance methods; Scoring matrices: BLOSUM and PAM; Pairwise alignment: Dot matrix method, alignment algorithms (global and local alignment, dynamic programming alignment), heuristic methods (FASTA, BLAST), uses; Multiple sequence alignment: Scoring an MSA, alignment methods (heuristic, iterative, genetic algorithm, simulated annealing and profile HMMs), uses of MSA.

MODULE IV:

- **Molecular phylogeny:** Introduction; Phenotypic and molecular phylogeny; Mechanism of molecular phylogeny: Base substitution and exon shuffling; Phylogenetic markers; Representation of phylogeny: Commonly used terminology w.r.t phylogenetic trees, types of trees; Molecular clocks; Steps in constructing a tree; Methods of phylogeny: Maximum parsimony, Maximum likelihood and Distance methods (UPGMA and NJ); An overview of the software used for phylogenetic analyses (BLASTree, Phylip, MEGA, McClad, Mesquit)
- **Genomics:** Definition; Structural genomics: Variation in size and complexity of genomes, organisation of nuclear DNA in eukaryotes (repetitive DNA, retrotransposons, transposons), genome mapping (use of RFLPs, sequence tags, SNPs, physical mapping); functional genomics (homology searches, protein domains, DNA microarrays and reporter sequences); comparative genomics (bacterial genomes- genome size, number of genes, horizontal gene transfer; eukaryotic genomes- genome size, number of genes, segmental duplications, multigene families, gene deserts, transposable elements, protein diversity, homologous genes, collinearity between related genomes).
- **Proteomics:** Introduction; categories (expression, cell map or interaction, functional, structural); 2-D gel electrophoresis, peptide mass fingerprinting, protein microarrays, mass spectroscopy

(The above-mentioned topics should be taught in the light of the recent developments in the field)

Suggested readings

Alberts B, Johnson A, Lewis J, Morgan D, Raff M, Roberts K, Walter P 2015 Molecular Biology of the cell 6e. Garland Science, Taylor and Francis Group, UK.

Brown TA 2007 Genomes 3. Garland Science Publishing, USA.

Brown TA 2016 Gene cloning and DNA analysis: An introduction 7e. Wiley-Blackwell, UK. Dale JW, von Schantz M 2007 From genes to genomes 2e. John Wiley and Sons Ltd., England.Durbin R, Eddy S, Krogh A, Mitchison G 1998 Biological sequence analysis. Cambridge University Press, UK.

Ghosh Z, Mallick B 2008 Bioinformatics: Principles and Applications. Oxford University Press, India.

Glick BR, Patten CL 2017 Molecular Biotechnology: Principles and applications of

recombinant DNA. ASM press, USA.

Mount W 2004 Bioinformatics and sequence genome analysis 2e. CBS Publishers, India. Primrose SB, Twyman RM 2006 Principles of gene manipulations 7e. Wiley-Blackwell, USA. Rastogi SC, Mendiratta N, Rastogi P 2008 Bioinformatics: Methods and Applications.

Genomics, Proteomics and Drug discovery. PHI Learning Pvt. Ltd., India.

Sensen CW 2002 Essentials of Genomics and Bioinformatics. Wiley-VCH, Germany.Singh BD 2003 Biotechnology: Expanding horizons. Kalyani Publishers, India.

Review articles and Research papers

Biswas S, Zhang D, Shi J 2021 CRISPR/Cas systems: opportunities and challenges for crop breeding. Plant Cell Reports 40: 979-998. DoI: https://doi.org/10.1007/s00299-021-02708-2

Bolanos-Villegas P 2020 Chromosome engineering in tropical cash crops. Agronomy 10: 122.

DoI: 10.3390/agronomy10010122

Gallo S, Furler M, Sigel RKO 2005In vitro transcription and Purification of RNAs of different size. Chimia 59(11): 812-816.

Gregorio NE, Levine MZ, Oza JP 2019 A user's guide to cell-free protein synthesis. Methods Protoc. 2: 24. DoI: 10.3390/mps2010024

Kaul T, Sony SK, Verma R, Motelb KFA, Prakash AT, Eswaran M, Bharti J, Nehra M, Kaul R 2020 Revisiting CRISPR/Cas-mediated crop improvement: Special focus on nutrition.J. Biosci. 45: 137. DoI: 10.1007/s12038-020-00094-7

Kim S 2021 CRISPR innovations in plant breeding. Plant Cell Reports 40: 913-914. DoI: https://doi.org/10.1007/s00299-021-02703-7

Louise van der Weyden, Allan Bradley 2006 Mouse Chromosome Engineering for Modeling Human Disease. Annu Rev Genomics Hum Genet 7: 247–276 DoI: 10.1146/annurev.genom.7.080505.115741

Matsuzaki H, Nakajima R, Nishiyama J, Araki H, Oshima Y 1990 Chromosome engineering in *Saccharomyces cerevisae* by using a site-specific recombination system of a yeast plasmid. J. of Bacteriology 172(2): 610-618.

Miladinovic D, Antunes D, Yildirim K, Bakhsh A, Cvejic S, Kondic-Spika A, Jeromela AM, Opsahl-Sorteberg H, Zambounis A, Hilioti Z 2021 Targeted plant improvement through genome editing: from laboratory to field. Plant Cell Reports 40: 935-951. DoI: https://doi.org/10.1007/s00299-020-02655-4

Schmidt C, Schindele P, Puchta H 2019 From gene editing to genome engineering: restructuring plant chromosomes via CRISPR/Cas. aBIOTECH https://doi.org/10.1007/s42994-019-00002-0

Sugiura M 1997 Plant in vitro transcription systems. Annu. Rev. Pl. Physiol. Pl. Mol. Biol. 48: 383-398.

Xing Z, Li Y, Pao A, Kaas G, Yu YE 2018 CRISPR/Cas9-facilitated chromosome engineering to model human alterations. DoI: http://dx.doi.org/10.5772/intechopen.70897

Recent issues of the relevant 'Annual Reviews' should also be consulted.

Practicals Based on Elective

Lab-5: DSC: MBO3P05: Molecular Biology & Plant Biotechnology

Objectives:

- To get hands-on experience in the laboratory techniques used in a specialized branch of Botany.
- To sensitize the student with the methods used to collect the data, analyses it and present in form of tables, charts etc.
- To train the student in writing the report.

Outcomes

- The student is trained in the lab techniques used in a specialized branch of Botany.
- The student presents the data in various forms and prepares the report.

List of Practicals:

Group A: MOLECULAR BIOLOGY **(Any 5)**

MAJOR

1. To detect molecular polymorphism in different species using a suitable technique.
2. To demonstrate the presence of a particular polypeptide by Western blotting.
3. To design PCR primers to isolate the given gene for cloning it in the given vector.
4. To perform ELISA testing.
5. To perform DNA ligation and analysis of ligated DNA on agarose gel.

6. To isolate and develop the protein profile of different plant species by SDS-PAGE.
7. To demonstrate bacterial transformation and selection of transformed cells.

MINOR

8. To work out the sequence from given autoradiogram and to identify it from Gene Bank by BLAST method.
9. To download the DNA sequences from databases and generate pairwise and multiple Sequence alignment.
10. To download the protein sequences from databases and generate pairwise and multiple Sequence alignment.

Group B: PLANT BIOTECHNOLOGY & PLANT BREEDING (Any 5)

MAJOR

1. To prepare Media for plant tissue culture
2. To surface sterilize the given seeds/explant for tissue cultural manipulation
3. To demonstrate callus induction using appropriate explants
4. To demonstrate organogenesis using appropriate explants.
5. To demonstrate the anther culture.
6. To isolate protoplast and determine its viability.
7. To fuse the protoplast for production somatic hybrid.
8. To study the activity of inducible gene in the seedlings challenged with elicitors.
9. To perform testing of Bt gene in cotton (ELISA or PCR).
10. To map the genes on the basis of given cross-over data.
11. Separation of amino acids by paper electrophoresis/ TLC method.
12. To study the growth characteristics of *E. coli* using plating and turbidimetric methods.

MINOR

13. To search literature database of different organisms.
14. To search the genes in the GenBank.
15. To use the various tools to retrieve information available from NCBI
16. To locate gene(s) on chromosomes for a given disease/disorder.
17. To prepare a phylogenetic tree using online database with the help of the software BLAST Tree/ PHYLIP/ MEGA/ McClad/ Mesquit.

SEMESTER-III

Lab 5 (MBO3P05): Elective: Molecular Biology and Plant Biotechnology

Section-A: SEE (50 Marks)

Time: 6 Hours **Full Marks: 50**

Q. 1 One major experiment **A** from Group A.	12
Q. 2 One minor experiment **B** from Group A.	8
Q. 3 One major experiment **C** from Group B.	12
Q. 4 One minor experiment **D** from Group B.	8
Q. 5 Spotting: **E, F, G & H (from group A & B)**.	10

Section-B: CIE (50 Marks)

INTERNAL **Full Marks: 50**

Q. 1 Viva-voce.	20
Q. 2 Practical record.	10
Q. 3 Tour Report / Permeant Micro-Preparations / Herbarium Records / Field Diary / Industrial Visit / Laboratory Visit / Collection, Preservation & Culturing of Materials / Excursion Report (Wherever applicable)	20

Elective Paper: DSC: MB03T11: Mycology and Plant Pathology- I

Objectives:

- To study the general features, nutrition and reproduction of microbes.
- To study the occurrence of fungi in association with plants and humans.
- To study the industrial uses of fungal products.

Outcomes

- The student is exposed to the variability in the microbes.
- The student understands various habitats of fungi and the role they perform therein.
- The student appreciates the array of molecules having diverse applications produced by fungi.
- The student is acquainted with the ways to employ fungi for commercial benefit.
- The student is skilled with the techniques to study the fungi in field and laboratory.

Module I:

General Microbiology

- **Bacteria** - Morphology, Size, Shape, Structure, Nutrition, Reproduction.
- **Actinomycetes -** Morphology, Size, Shape, Structure, Nutrition, Reproduction.
- **Rickettsia -** General Characters.
- **Archaea** - Morphology, Size, Shape, Structure, Nutrition, Reproduction.
- **Viruses** - General Characteristics, Structure, Classification, Replication (Lytic Cycle & Lysogeny).
- **Viroid's** - General Characteristics.
- **Fungal diversity** in different ecosystems, effect of environment on fungal growth and behaviour.

Module II:

Mycorrhiza, Rhizosphere, Phyllosphere, Medical Mycology

- **Mycorrhiza** - Characters, types, mycorrhiza in plant disease control.
- **Rhizoshere & 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*; Aspergillosis; fungi allergic to human beings.

Module III:

Production of Metabolites by Fungi

- **Fungal Metabolites -** General account of production and application: Primary metabolites (vitamins, proteins), secondary metabolites (antibiotics, pigments, alkaloids).

A) Fungal Metabolites:

- Antibiotics - Penicillin, Cephalosporin, Griseofulvin.
- Industrial Production of Penicillin
- Enzymes - Fungal source and types, mode of action and applications: Amylase, lipases, pectinases, and cellulases.
- Organic Acids- Fungal source, chemical nature and industrial applications: Critic acid, gluconic acid, lactic acid.
- Glycerol and adhesive and bio-polymer from yeasts.

B) Non-industrial fungal metabolites: Phytoalexins and Mycotoxins.

Module IV:

Fungi as Welfare to Human Beings:

- **Fungi in Food Processing -** Soybean products, cheese, fermented milk, other fermented foods.
- **Fungi as Food** - Edible mushrooms, methods of their cultivation.
- **Biodeterioration & Biodegradation -** Biodeterioration of non-cellulosic materials (leather, plastics, hydrocarbons, pesticides). Biodeterioration of cellulosic materials.
- **Fungi In Plant Disease Control** - Selection, production and formulation of fungal biopesticides and commercial use of biocontrol agents

(The above-mentioned topics should be taught in the light of the recent developments in the field)

Suggested readings

Alberts B, Johnson A, Lewis J, Morgan D, Raff M, Roberts K, Walter P 2015 Molecular Biology of the cell 6e. Garland Science, Taylor and Francis Group, UK.

Agrios, G.N. (1980) Plant Pathology, academic Press, INC, New York. Ainsworth, G.C. and A.S.Sussman (eds). The Fungi, An advance Treatise Vol. I, II, III & IV. Academic Press, New York.

Alexopoulos, C.J. (1962). Introductory Mycology John Wiley Eastern Pvt. Ltd. Alexopoulos, C.J. and

Mims C.W. (1979). Introductory Mycology 3rd Edition, John Wiley and Sons, Inc. Wiley, New York.

Alexopoulos, C.J., Mims and Black well (1996) 4th ed. John Wiley and Sons, Inc. Wiley, New York

Aneja, K.R. (1993) Experimental in Microbiology, Plant Pathology & Tissue Culture, Wiswa Prakashan, New Delhi.

Barnett, J.H. (1968) Fundamentals of Mycology. The English Language Book Society and Edward Arnold Publication, Limited.

Bessey, E.A. (1950) Morphology and Taxonomy of Fungi. The Blakiston co. Philadelphia.

Bilgrami, K.S. and H.C. Dube (1985) A text Book of Modern Plant Pathology, Vikas Publication House, New Delhi.

Dube, R.C. and D.K. Maheshwari (1999) A. Text Book of microbiology, S.Chand & Co. Ltd.

Dube, R.C. and D.K. Maheshwari (2000) Practical Microbiology -S.Chand & Co. Ltd.

Eggins, H.O.W. and Allsop (1975) The Filamentous Fungi Vol. I Industrial Mycology (Biodetoriation and Biodegradation by Fungi) Eds. J.E. Smith and D.R. Berry Edward Arnold, London.

Emmons, C. W., C. H. Bin ford, J.P. Utz and Know Chung (1977) Medical Mycology, Lea and Febigo, Philadelphia.

Gupta, V.K. and M.K. Behl (1994) Indian Plant Viruses and Mycoplasma Kalyani Publishers, Ludhiana. Holliday, P. Fungus disease of tropical plants (1980), Cambridge University Press, Cambridge.

Jha, D.K. (1993) A Text Book of Seed Pathology, Vikas Publication House. Mehrotra, R.S. (1989) Plant Pathology, Tata McGraw Hill.

Mehrotra, R.S. and K.R. Aneja (1998) An Introduction to Mycology, New Age Intermidiate Press.

Pelzer, M.J., Jr. Cahn, E.C.S. and N.R. Krieg (1993) Microbiology, Tata McGraw Hill.

Preece and Dickeson. Ecology of leaf surface microorganism Academic Press, New York. Rangaswamy, G. and A. Mahadevan (1999) Diseases of Crop Plant in India, Prentice Hall of India.

Raychoudhari, S.P. and Nariani, T.K. (1977) Virus and Mycoplasma Diseases of Plant in India, Oxford and IBH Publication Co.

Schlegel, H.G. (1996) General Microbiology, 7th Edition, Cambridge University Press. Snowdon, A.L. (1991) A colour Atlas of Post harvest diseases & disorders of fruits & vegetables Vol. I & II Wolfe Scientific, London.

Sunder Rajan, S. (2001) Tools and Techniques of Microbiology, Anmol Publ. New Delhi.

Thind, T.S. (1998) Diseases of field crops and their management, National Agricultural Technology, Information Centre, Ludhiana.

Vaidya, J.G. (1995) Biology of the fungi, Satyajeet Prakashan, Pune. Walker, J.C. (1968) Plant Pathology, McGraw Hill, New York.

Walker, J.G. (1952) Diseases of Vegetables Crops. McGraw Hill, New York. Recent issues of the relevant 'Annual Reviews' should also be consulted.

Practicals Based on Electives

Lab-5: DSC: MBO3P05: Mycology and Plant Pathology.

List of Practicals:

1. To learn the technique of micrometry and measurement of organisms.
2. To learn the techniques of sterilization viz., moist heat, dry heat, chemical and radiation.
3. To learn the technique of drawing Camera Lucida diagrams and knowledge of computer-based photomicrography and image processing.
4. To prepare various culture media for the cultivation of fungi and bacteria.
5. To monitor and analyse the aero- mycoflora.
6. To isolate & identify the phyllosphere mycoflora.

7. To demonstrate the antifungal activity of various antibiotics and leaf, flower and root extract.
8. To study the toxicity of fungi in relation to seed germination and seedling abnormality.
9. To cultivate the mushrooms.
10. To demonstrate the biodegradation of organic waste.
11. To isolate the soil fungi by soil plate (War cup) and serial dilution (Walksman) method.
12. To isolate and identify the rhizosphere mycoflora.
13. To isolate the external and internal seed borne mycoflora (Cereals, pulses, oil seeds, fruit seeds) by blotter and agar plate method.
14. Diagnosis of plant diseases and proof of pathogenicity according to Koch's postulates.
15. To calculate the spore count using haemocytometer.
16. To perform qualitative estimation of fungal enzymes– cellulases, lipase, protease and amylases.
17. To estimate the sugars, proteins and amino acids in fungal mycelium and culture filtrate.
18. To study the mycorrhiza (VAM).
19. To carry-out the monographic study of locally available plant diseases caused by fungi (at least 10) (Plant disease diagnosis by studying symptoms in the field).
20. To study the locally available crop plant diseases caused by bacteria (at least 5)
21. To study the locally available plant diseases caused by viruses & phytoplasma (at least 5)
22. To demonstrate the morphological & physiological changes in diseased plants.
23. Qualitative and quantitative Biochemical tests of fungal metabolites: Organic acids- Critic acid, gluconic acid, lactic acid, kojic acid, itaconic acid. Fungal Enzymes – Amylase, proteases, lipases, pectinases, cellulases and xylanases. Phytoalexins and Mycotoxins, Alkaloids
24. Preparation of semi-permanent slides of diseased material, eg. Leaf spots, blights, mildews, rots, wilts, rusts and smuts
25. To prepare and present the herbarium of pathological specimens available in the region (at least 15)
26. To conduct field visits to different localities and to visit the Agriculture University, Plant pathology research centres etc.
27. Demonstration of antagonistic fungi: a) Antibiosis; b) Competition; c) Mycoparasitism

SEMESTER-III

Lab 5 (MBO3P05): Elective: Mycology and Plant Pathology.

Section-A: SEE (50 Marks)

Time: 6 Hours **Full Marks: 50**

Q. 1 To identify giving salient characters of fungi from the given two culture A.	10
Q. 2 To identify the two given diseased material, its symptoms and characters B.	10
Q. 3 To study the effect of sugar concentration on the conidial germination and presentation of data on the graph paper C.	05
Q. 4 To demonstrate pure culture techniques /transfer techniques E.	10
Q. 5 To draw a camera lucida diagram of the given fungus/microorganism with correct dimensions D.	05
Q. 6 Biochemical test: (Fungal - metabolite, enzymes mentioned in syllabus)	05
Q. 7 Spotting: F and G.	05

Section-B: CIE (50 Marks)

INTERNAL **Full Marks: 50**

Q. 1 Viva-voce.	20
Q. 2 Practical record.	10
Q. 3 Tour Report / Permeant Micro-Preparations / Herbarium Records / Field Diary / Industrial Visit / Laboratory Visit / Collection, Preservation & Culturing of Materials / Excursion Report (Wherever applicable)	20

Elective Paper: DSC: MB03T11: Plant Physiology - I

Objectives:

- Understanding Plant growth and Development.
- Understanding the function of different growth regulators.
- Understanding seed physiology
- Understanding stress physiology

Outcomes

- After successful completion of the course the students will be able to
- Understand the aspects of plant growth and development
- Understand the aspects of seed physiology and stress physiology

Module I:

- **Plant Growth and Development:** Growth, Differentiation and development. genetic and hormonal Control of growth and development, Pattern of growth and development, Plant growth Kinetics and Growth measurement

Module-II:

- **Photomorphogenesis & Plant Growth Regulators (Hormones):** Plant photoreceptors, Structure, function, photomorphogenic responses and coaction of phytochromes, cryptochromes and phototropins.
- **Plant Growth Regulators (Hormones):** Site of synthesis, biosynthetic pathways, Physiological influence on plant growth development and mechanism of action of individual group of hormones- Auxins, Gibberllins, cytokinins, Abscisic acid and Ethylene, Brassinosteroids, Jasmonic acids, Polyamines, salicylic acid:

Module-III:

- **Seed Structure & Development:** Structure of Monocot, Dicot seed, Biochemical changes during development of seeds.
- **Seed Dormancy:** Importance and types of dormancies, overcoming seed dormancy, bud dormancy. Factors responsible for dormancy, Mechanism of dormancy, Methods of breaking the seed dormancy.
- **Germination Of Seed:** Types of germination, chemical Changes during germination, mobilization of reserve Food during germination, hormonal Control of seed Germination

- **Post Harvest Physiology:** Ripening of fruit and its regulation, metabolism of leafy vegetables during storage.

Module-IV:

Stress physiology:

- Definition of plant stress, Response of plants to biotic (pathogen and insect) and abiotic Stress, stress-sensing mechanisms in plants.
- Biotic Stress - Plant defines mechanism and resistance to biotic stress (HR, SAR).
- Abiotic Stress - Signaling pathways activated in response to abiotic stress, developmental and physiological mechanisms that protect plants against abiotic stress.
- Water stress - Causes of water stress, effect of drought and flooding on physiological processes in plants, tolerance mechanism.
- Salt stress - definition of saline soil, physiological responses of plants to salinity stress, halophytes, mechanism of salinity tolerance in higher plants.
- Thermal stresses -mechanism of high and low temperatures tolerance, cold hardening, role of HSP.
- Oxidative stress - Generation of reactive oxygen species, effect of ROS on metabolism, ROX detoxification mechanisms in plants.

(The above-mentioned topics should be taught in the light of the recent developments in the field)

Suggested readings

Asana, R.D. and Sarin M.N. (1968): Crop Physiology in India IARI Publ.

Abdelhamid Elaissari, (2008). Colloidal Nanoparticles in Biotechnology, John Wiley

Apps et al., (1992). Biochemistry, ELBS.

Atwll, B.J. Kriedcrmann, P.E. and Jumbull, C.G.N. (eds). 1999. Plants in action: Adaption in Nature Performance, in Cultivation, MacMillan Education.sydney, Australia.

Buchanan, B. B., Gruissem, W. and Jones, R.L. 1989. Biochemistry and Molecular Biology of plants. American Society of Plant Physiologists, Maryland, USA.

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

Charles PP and Frank JO, (2006). Introduction to Nanotechnology, Wiley India Ed.

Cherry, J. H. 1989. Environmental stresses in plants. biochemical and physiological mechanisms.

Conn E.E, Stumpf, Bruening G, Doi RH. (2005) . Outlines of Biochmistry 5/Ed, Wiley & Sons Pvt.ltd.

Caret et al., (1993). Inorganic, Organic and Biological Chemistry, WMC Brown Pub. USA.

Dey, P. M. And Harborne, J. B. 2000: Plant Biochemistry, Harcourt Asia PTE Ltd. A Harcourt Publishers International Company, 583 Orchard Road 09-01 Forum Singapore-238884.

Dennis, D.T., Turpin, D. H., Lefebvrc, D.D. and Layzell, D.B. (eds).1997. Plant Metabolism (2nd Ed.) Longman, Essex, England.

Evans, L.T. 1972. Crop physiology

Fageria, N. K. 1992. Maximizing crop yield.

Fertilizer association of India (1974): Fertilizer handbook of Usage.

Fitter, A. H. and Hay, R. K. M. S. (1987): Environmental Plant Physiology.

Gupta, U. S. (1972): Crop Physiology.

Gupta, I. S. (1986): Physiological aspects of dryland farming.

Gupta, U. S. (1975): Physiological aspects of dryland farming.

Gaiston, A.W.1989. Life Processes in Plants. Scientific American Library, Springer-Verlag, New York, USA.

Hans-Walter Heldt (2004). Plant Biochemistry. Elsevier Academic Press, 200-Wheeler Road, Burlington, MA 01803, USA, 525 B Street, Suite 1900, San Diego, California 92101-4495, USA

Hooykass P.J.J., Hall, M. A. and Libbenga, K.R. (eds).1999. Biochemistry and molecular Biology of plant Horm. Elsevier, Amsterdam, The Netherlands.

Hopkins, W.G. 1995. Introduction to Plant Physiology. John Wiley & Sons, Inc., New York, USA.

Hale, M.C. and Orcutt, D.M. (1987): The Physiology of Plants Under Stress. ICA handbook of Fertilizers.

Jain J.L. et al., (2008). Fundamentals of Biochemistry, Chand, New Delhi

Kozlowski, T. T. (1984): Flooding and Plant Growth. 11. Levitt, J. (1969, 1980): Responses of Plants to Environmental Stress.

Lodish, H., Berk, A., Zipursky S.L., Matsudaira, P., Baltimore, D and Darnell, J. 2000.

Molecular Cell Biology (4thed). W. H. Freeman and Company. New York, USA.

Moore, T.C. 1989. Biochemistry and Physiology of Plant Hormones (2nded). Springer- Verlag, New York, USA.

Mansfield, C.A. (1976): Effect of air pollutant on plants.

Marschner, H. W. (1986): Mineral nutrition of Higher Plants.

McLaren, J.S. (1985): Chemical manipulation of crop growth and Development.

Mehrotra, R.S. (1980): Plant Pathology.

Mahadevan, A and Sridhar R. (1986) Methods in Physiological plant Pathology, Sivakami Publications, Madras

Nobel, P.S.1999. Physicochemical and Environmental Plant Physiology (2nd ed). Academic Press, Diego, USA.

Nelson D.L, Cox M.M. (2005). Lehninger Principle of Biochemistry, W.H. freeman and Company, New York

Nickell, L.G. (1986): Plant growth regulators in Agriculture.

Pessarkli, M. (2004): Handbook of Plant and Crop Physiology, Marcel Dekkar Inc. NY.

Pessarkli, M. (2005): Handbook of Photosynthesis.

Pradeep T. (2007). NANO: The Essentials – Understanding Nanoscience and Nanotechnology, TATA McGraw – Hill Education.

Paleg, L.G. and Aspinal, D. (1982): The Physiology and Biochemistry of Drought resistant in Plants.

Pojakoff Mayber A. and Gale, J. (1975): Plants in saline environment.

Rawn, D. (1989). Biochemistry, Neil Patterson.

Ranjan, purohit, Prasad 2003: Plant Hormones Action and Application, Agrobios (India), agro house, behind Nasrani cinema Chopasani Road, Jodhpur -342002

Rice, E. L. (1982): Allelopathy (Physiological Ecology).

Raven, P.H., Evrt, R.F. and Eichhorn, S. 1992. Biology of Plants (5th edition). Worth, New York.

Rastogi, S.C (2003). Outlines of Biochemistry, CBS Publishers &Distributors , New Delhi

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

Steeves, T.A. and Sussex, I.M., 1989.Patterns in Plant Development (2nd edition).

Cambridge University Press, Cambridge.

Stryer, L., (1988). Biochemistry, WH Freeman & Co., NY.

Satyanaryana U, Chakrapaani U, (2006). Biochemistry, Books and Allied (P)Ltd.

Sharma, S. Raghavan, V. 1999.Developmental Biology of Flowering Plants. Springer-Verlag, New York.

Sinha S.K., Sane P.V., Bhargava S.C. and Agarwal P.K. (1990): Proceeding of International Congress of Plant Physiology Vol. I & II.

Salisbury, F.B. and Ross, C.W.1992: Plant Physiology (4thed). Wadsworth Publishing Co., California, USA.

Singhal G.S., Renger, G., Sopory, S.K., Irrgang, K.D. and Govindjee.1999: Concepts in

Photobiol Photosynthesis and Photomorphogenesis. Narosa Publishing House, New Delhi.71

Turner, N. C. and Cramer, P.J. (1980): Adaptation of plants to water and high temperature stress.

Taiz, L. and Zeiger, E. 1998: Plant Physiology. Sinaucr Associates, Inc., Publishers, Massachus, USA.

Thomas, B. and Vince-Prue, D.1997: Photoperiodism in Plants (2nd ed).Academic Press, San Diego, USA.

Upeke, L. K. (1982): Tropical tree crops.

Westhoff, P.1998: Molecular Plant Development: From gene to plant. Oxford University Press, Oxford, UK.

Zuley G.L., (1998). Biochemistry, Wm.C. Brown Publishers USA.

Practicals Based on Electives

Lab-5: DSC: MBO3P05: Plant Physiology

List of Practicals:

1. Estimation of phenols from given plant material.
2. Estimation of proline from plant tissues under different environmental and Physiological conditions.
3. Study the effects of red and infrared radiation on seed germination as affected.
4. Determination of gibberellic acid by half seed (cereal) method.
5. Demonstration of effects of auxin on abscission.
6. Demonstration of effects of cytokinin on senescence.
7. Demonstration of effects of abscission acid on stomatal regulation.
8. Preparation of cytoplasmic and chloroplastic LPC.
9. Estimation of Vitamin C from suitable plant material.
10. Estimation of alkaloids from medicinal plants.
11. Study of changes in starch / protein content during seed development.
12. Study of lipid accumulation during development of oil seeds.
13. Study of effect of PEG induced water stress on seed germination.
14. Study the effect of ZnSO4 (800ppm) solution on (paddy) seed germination
15. study the physical and chemical methods for breaking the seed dormancy.

SEMESTER-III

Lab 5 (MBO3P05): Elective: Plant Physiology

Section-A: SEE (50 Marks)

Time: 6 Hours **Full Marks: 50**

Q. 1 One Major Experiment from Special paper- I A.	10
Q. 2 One Minor Experiment from Special paper- IB.	10
Q. 3 One Major Experiment from Special paper- II C	10
Q. 4 One Minor Experiment from Special paper- IID.	10
Q. 5 Identification and comments on given two spots (E, F)	10

Section-B: CIE (50 Marks)

INTERNAL **Full Marks: 50**

Q. 1 Viva-voce.	20
Q. 2 Practical record.	10
Q. 3 Tour Report / Permeant Micro-Preparations / Herbarium Records / Field Diary / Industrial Visit / Laboratory Visit / Collection, Preservation & Culturing of Materials / Excursion Report (Wherever applicable)	20

Elective Paper: DSC: MB03T11: Reproductive Biology of Angiosperms- I

Objectives:

- To study the gametogenesis in Angiosperms in detail.
- To study the causes and implications of sterility in Angiosperms.
- To study the causes of incompatibility in Angiosperms.

Outcomes:

- The student gets in-depth understanding of the development of male and female gametes in Angiosperms.
- The student recognizes the role of various agencies involved in pollination and mechanisms leading to fertilization.
- The student understands the causes of sterility and incompatibility and is equipped with the skill to overcome/exploit sterility and incompatibility.

Module I:

- **Introduction:** Retrospect and Prospects, floral evocation and development of floral meristem, methodology of studying reproductive biology of angiosperms (developmental cytology, genetics), genetical and molecular perspectives, gene expression during anther and pollen development, embryo specific genes, scope of molecular embryology.
- **Anther Development:** Morphology and structure; Ontogeny, anther wall, wall layers – epidermis, endothecium middle layers; Tapetum– general organization, ultrastructure, cytology of tapetum, synthesis of sporopollenin– Deposition, functions of tapetum, causes of sterility, ubisch bodies/orbicules, its origin, role, tapetal membrane, pollenkitt and tryphine; Sporogenous tissue– Ultrastructure, microsporogenesis, cytoplasmic organelles during DNA synthesis, meiosis, RNA synthesis and protein synthesis, plasmodesmata, control of meiosis, duration of meiosis, synthesis of callose, functions of callose, microspore tetrads, cytokinesis, unusual features.

Module II:

Anther development cont. …..

- **Pollen development and maturation:** Morphogenesis of pollen walls, callose walls, exine, sporopollenin synthesis, intine, pollen wall proteins, structural adaptations of pollen for dispersal , first haploid mitosis (formation of vegetative and generative cells,) biochemical and ultrastructural changes, role of cytoskeleton appearance cell plate (wall), pollen

cytology, organelle inheritance, formation of vegetative and generative cells, division of generative cell and formation of the male germ unit, sperm dimorphism, gene expression during pollen development– analysis of pollen characters, nucleic acid and protein metabolism, pollen wall proteins and allergens.

- **Pollen abortion and male sterility:** Phenotypic and genotypic aspects of male sterility, structural, developmental and functional aspects of male sterility, physiological and biochemical aspects of male sterility, role of mitochondrial genome in male sterility.

Module III:

- **Megasporogenesis and Megagametogenesis:** Carpel determination, ovular morphology (integument type, micropyle type, ovule position), Ovule initiation, nucellus, vascular supply of the ovule. Special structures: (Obturator, Hypostase, epistase, Arils, Reduced ovules, megaspore haustoria); Megasporogenesis: Megaspore mother cell (megasporopyte), meiotic division, formation of megaspore tetrad, types of megaspore tetrad, the functional megaspore, megagametogenesis, formation of embryo sac or female gametophyte, types of megagametophyte development (monosporic, bisporic, tetrasporic), organization of embryo sac, structure of embryo sac cells (molecular and ultrastructural aspects), the synergids, the egg cell the central cell, the antipodal cells. Gene function or molecular biology during megagametogenesis, modular hypothesis of female gametophyte evolution, enzymatic isolation of female gametophyte; Nutrition of the embryo sac.

Module IV:

Floral Biology (Pollination Biology):

- Types pollination mechanism (Anemophily, Hydrophily, Zoophily). Zoophily (Details)
  i. Entomophily - Hymenoptera (Bee pollination or melittophily or hymenopterophily), Diptera (Fly pollination or sapromyiophily), Coleoptera (beetle pollination or canthorophily), Lepidoptera or moth pollination (Phalaenophily), Thysanoptera (thrips), Hemiptera.
  ii. Ornithophily (Bird Pollination),
  iii. Chiropteriphily (Bat Pollination)
  iv. Pollination by non-flying mammals.
  v. Malacophily (slug and snails)
- Special differentiation associated with pollinator attraction (forms of pollen flowers, pollen as reward, heteranthery, pollen heteromorphy); Nectaries, Nectar flowers and nectar;

Elaiophores, floral oil and oil flowers; Resin glands and resin flowers; Osmophores, floral scent, and perfume flowers.

Pollen-Pistil interaction:

- **Introduction** - Pollen grains and its structure, origin of exine and intine proteins, structure of stigma and style, dry and wet stigma, nature of stigma covering, style– solid or closed style and hollow open style; Post pollination events: pollen landing, pollen tube entry into the stigma, pollen tube growth through the style, chemotrophism, biochemistry of pollen germination (RNA metabolism during pollen germination and pollen tube growth, protein metabolism, structure of the pollen tube (dictyosomes, vesicles), pollen tube wall, pollen tube cytoskeleton, calcium gradient in the pollen tube, growth of the pollen tube.
- **Incompatibility** - Interspecific incompatibility and Intraspecific incompatibility or self-incompatibility: i) Heteromorphic, ii) Homomorphic; Factors affecting self-incompatibility, biochemical basis or recognition of self-incompatibility, importance of self-incompatibility, methods of overcoming self-incompatibility, in vitro pollination and in vitro fertilization, parasexual hybridization.

(The above-mentioned topics should be taught in the light of the recent developments in the field)

Suggested readings:

Johri, B.M. (Ed) (1982) Experimental Embryology of vascular plants. Springer-Verlag, Berlin.

Johri, B.M. (Ed.) (1984) Embryology of Angiosperms. Springer-Verlag, Berlin.

Nettancourt, de D. (1977) Incompatibility in Angiosperms. Springer-Verlag, Berlin.

Raghvan V. (1992) Developmental Biology of flowering plants, Springer-Verlag, Berlin.

Raghvan V. (1997) Molecular Embryology of Flowering plants. Cambridge Uni. Press.

Simpson, M.G. (2010) Plant systematics. Elsevier.

Recent issues of the relevant 'Annual Reviews' should also be consulted.

Practicals Based on Electives

Lab-5: DSC: MBO3P05: Reproductive Biology of Angiosperms

List of Practicals:

1. Anther development: Study from permanent micro-preparations (male archesporium, anther wall, endothecium, tapetum, Sporogenous tissue, microsporagenesis, microspore tetrad, cytokinesis, structure of mature pollen grain.)
2. Pollen development and maturation, pollen wall, exine and intine.
3. Megasporogenesis: integument, endothelium, micropyle types, ovule position, nucellus, oblurator, hypostase), megaspore tetrad, functional megaspore, monosporic, bisporic and tetrasporic embryo sac.
4. Floral Biology: Pollination.
5. (Students are here by informed that they should take the photographs in nature showing different type of pollination photo graphs should be pasted in the practiced record to witness their homework.
6. Study of pollen germination: Hanging drop technique.
7. To study the fertilization, endosperm development, and embryo development, polyembryony by observing the permanent slides.
8. To study apomixis through permanent micropreparations.
9. Technique of plant tissue culture: Sterilization; Preparation of MS medium, Growth factors and their role, pH of the medium, light and temperature, plant material to be used; Callus culture, Embryogenesis; Cell suspension culture; Protoplast culture.

SEMESTER-III

Lab 5 (MBO3P05): Elective: Reproductive Biology of Angiosperms

Section-A: SEE (50 Marks)

Time: 6 Hours **Full Marks: 50**

Q. 1 Dissect and mount the endothecium/endosperm from the given material A.	08
Q. 2 Dissect and mount the given stage of embryo from the material B.	08
Q. 3 In vitro pollen germination percentage and pollen tube growth. Record the data under given conditions C.	08
Q. 4 Study the Morphology of pollen grain D.	08
Q. 5 Localize the biochemical compound in a given plant material E.	04
Q. 6 Draw the camera lucida diagram of an embryological stage F.	04
Q. 7 Spotting: G and H.	10

Section-B: CIE (50 Marks)

INTERNAL **Full Marks: 50**

Q. 1 Viva-voce.	20
Q. 2 Practical record.	10
Q. 3 Tour Report / Permeant Micro-Preparations / Herbarium Records / Field Diary / Industrial Visit / Laboratory Visit / Collection, Preservation & Culturing of Materials / Excursion Report (Wherever applicable)	20

Elective Paper: DSC: MB03T11: Palaeobotany-I

Objectives:

- To study Palaeontology/ Palaeobiology and Palaeobotany with a focus on understanding the fossils and their significance in reconstructing Earth's history.
- To study fossil systematics, reconstruction and nomenclature, in order to interpret evolutionary process.
- To study the methods of age determination and modes of preservation of fossils.
- To understand laboratory-and field-based methods, advanced imaging and analytical techniques for fossil study and their applied aspects.

Outcomes:

- The student will comprehend the role of fossils in reconstructing past climatic conditions, environments, ecosystems, and evolutionary relationships among organisms.
- The student will gain knowledge of systematics, hierarchical classification of fossil taxa, from species to higher taxonomic ranks (e.g., family, order, class), and the evolutionary implications of taxonomic groupings/ cladistics studies.
- The student will know the methods of age determination, as well as the modes of preservation of fossils and the associated processes.
- The student will acquire proficiency in the methods used to study fossil specimens, and understand the Applied Aspects of Palaeobotany.

Module I:

- **Introduction:** Meaning and Scope of Palaeontology/Palaeobiology and Palaeobotany; Types of Rocks with special reference to the rocks that bear the fossils; Geological Time Scale - The General Concept and the same from the point-of-view of Plants and Palaeoclimate; Fossiliferous Localities, in general, and Important Deccan Intertrappean Localities

Module II:

- **Fossil Systematics:** International Code of Nomenclature for algae, fungi and plants (ICN for algae, fungi and plants); Recommendations about taxa; Cladistic Studies leading to the Construction of Phylogenetic Trees (Cladograms/Phylograms); Reconstruction Methods of Reconstruction and Nomenclature, (Whole Taxa and Environment) and Nomenclature,

Biomarkers as Tool in Reconstruction of Palaeoenvironment; Problems in Nomenclature, Fossil Plant Biomolecules and Chemosystematics, Molecular Taphonomy.

Module III:

- **Dating Methods (Age determination):** Radiometric Dating (Radioisotopic Techniques), Geomagnetic Polarity Timescale, Luminescence Dating, Biological Correlation, Molecular Clocks Ways, the Plants/Fragments get into Fossil Records (Modes of Preservation with examples): Autochthonous (in situ), Hypautochthonous (Transported), Allochthonous Assemblages; Factors determining the quality of Fossils;
- **Types of Fossils and Associated Fossilization Process/s (with suitable examples), and Methods to Study them :** Conditions favouring Fossilizations; a) Main Types - 1) Adpressions : Impressions and Compressions (Phytoleims), Coalified Compressions (siltstone, Shale, and fine-grained Sandstones); 2) Casts and 3) Moulds; 4) Authigenic Preservations; 5) Permineralization - Silicification (Petrifaction), Calcification (Limestones), Pyritization and Phosphatic Compounds, Coal-balls; 6) Unaltered Plant Forms (Mummifications); Amber and Diatomite; Other Methods like Wildfires, Volcanic Events (Fossil Charcoal called Fusiain), Ice and Snow, 7) Miscellaneous types.

Module IV:

- **Methods of Studying Fossil Specimens** - Morphology of Adpressions, Macrophotography, Electron Microscopy, Film Transfers for compressions, Sectioning and "peel" method for permineralizations, Extracting in situ pollen and spores, Maceration, Cuticles and Epidermal Structures.
- **Applied aspects of Palaeobotany** - Academic uses (in Evolution / Phylogeny and Classification, Fossil fuels including Coal, Coal Petrology and Palynological studies, Aesthetic value and other miscellaneous uses.

(The above-mentioned topics should be taught in the light of the recent developments in the field)

Suggested readings:

Agashe, S.N. (1995), Palaeobotany, Oxford & IBH, New Delhi

Arnold, C.A. (1947): Introduction to Palaeobotany, Mc-Graw Hill Book Co. Inc., New York and London.

Coulter J.M. & Chamberlain C.J. (1978): Morphology of Gymnosperms, Central Book Depot, Allahabad.

Christopher J. Cleal, Barry A. Thomas (2009) Introduction to Plant Fossils Cambridge Press

K.J. Willis, J.C. McElwain 2nd Ed (2014) The Evolution of Plants Oxford University Press

Eames, A.J. (1974): Morphology of Vascular Plants- lower groups, Tata Mc-Graw Hill publishing Co., New Delhi

Michael Krings, Carla J. Harper, Nestor Ruben Cuneo, Gar W. Rothwell (2018) Transformative Palaeobotany Academic Press (Elsevier)

P.C. Trivedi (2008) Palaeobotany to Modern Botany, Pointer Publications Jaipur Raj. India

Siddiqui, K.A. (2002) Elements of Palaeobotany, Kitab Mahal, Allahabad.

Spicer, R.A. & Thomas, B.A. (1986) Systematic and taxonomic approaches in Palaeobotany. Systematic Association Special Volume

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

Thomas, B.A. & Spicer R.A. (1987): The Evolution and Palaeobiology of land plants Discordies Press, Fortland, USA.

Thomas N. Taylor, Michael Krings, Edith L. Taylor (2015) Fossil Fungi Academic Press (Elsevier)

On line Journals available on UGC -VSAT

Practicals Based on Elective

Lab-5: DSC: MBO3P05: Palaeobotany

Objectives:

- To get hands-on experience in the laboratory techniques used in a specialised branch of Botany - Palaeobotany.
- To sensitise the student to gain a comprehensive understanding of geological and palaeobotanical concepts
- To train the student in Palaeobotany through theoretical study, practical exercises, and fieldwork experiences.

Outcomes:

- The student is trained in the lab techniques used in a specialised branch of Botany.
- The student is skilled in techniques for on-site fossil identification and subsequent documentation
- The student will comprehend the composition and diversity of different life forms and plant species during the Intertrappean period of the region.

List of Practicals:

1. To study Stratigraphy Maps of India and the World
2. To study Geological Maps of India
3. To study Geological column and time scale.
4. To study different rocks types.
5. To use different laboratory techniques for studying different fossil types. (Ground sectioning, peel technique)
6. To study different types of fossils
7. To study plant fossils as per syllabus from specimens and slides.
8. To study Deccan Intertrappean flora of India- (Pteridophytes, Gymnosperms, Angiosperm- roots, stems, leaves, flowers, fruits and seeds etc).
9. To write monograph based on the above-mentioned topics.
10. To study important features of spores and pollen morphology and technique to study them (Maceration)
11. To study wood anatomy of fossils.
12. To undertake exploration and excursion to different fossiliferous localities.

13. To prepare practical record based on the above topics.
14. To Submit the tour report

SEMESTER-III

Lab 5 (MBO3P05): Elective: Palaeobotany

Section-A: SEE (50 Marks)

Time: 6 Hours **Full Marks: 50**

Q. 1 Preparation of slide by maceration technique of a given material **A**. 10

Q. 2 Write monographs on the given specimens **B, C, D** and **E**. 20

Q. 3 Comment on the spots **F, G, H** and **I.** 20

Section-B: CIE (50 Marks)

INTERNAL **Full Marks: 50**

Q. 1 Viva-voce. 20

Q. 2 Practical record. 10

Q. 3 Tour Report / Permeant Micro-Preparations / Herbarium Records / Field Diary / Industrial Visit / Laboratory Visit / Collection, Preservation & Culturing of Materials / Excursion Report (Wherever applicable) 20

Elective Paper: DSC: MB03T11: Palynology - I

Objectives:

- To make aware about the science of Palynology, it's scope & applications.
- To get acquainted with the structure of stamen & pistil and their importance.
- To study pollen morphology, pollination, floral adaptations to different pollinators, applications of pollen biology. To study paleopalynology & its applications.
- To get knowledge through melissopalynology on honeys & pollen loads, methods of analysis, importance in agriculture, various uses of honeys & bee pollen in medicine, cosmetics etc. for wellbeing of human

Outcomes:

- To understand the different aspects of pollen, pistil and pollination Applying knowledge with reference to agriculture, horticulture, medicine.
- To get acquainted with reproductive plant organs as stamen & Pistil
- To know the various pollination methods, plant-pollinator interactions, various pollinating agents useful for plant breeding experiments.
- To identify and classify palynomorphs and use palynofacies to reconstruct sedimentary environments and evaluate their oil/ petroleum, coal potential
- To assess the quality of honeys and pollen loads. To apply the knowledge gained in the melissopalynological studies in exploring different types of honeys, checking adulteration of honeys, identification of poisonous honeys, and use of honeys & bee pollen in curing human ailment, its different uses in agriculture and medicine.

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, 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, special devices associated with pollinator attraction - pollen, nectar, Elaiophores, resin glands, osmophores, floral scent and perfume flowers.
- Palaeopalynology: - Definition, Palynomorphs, Methods in Paleopalynology: Sample Collection, Palynological Extraction, Palynological Sample Mounting and Observation, Palynological Analysis
- Applications of Paleopalynology, Role of spores and pollen in stratigraphy, index spores.

Module III:

- Ae 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, sporoderm stratification, Apertures-NPC System of classification, Apertural types, Exine ornamentation, LO analysis, evolutionary trends in exine structure, trends of evolution in apertural pattern, Techniques for the preparation of pollen slides, LM, SEM and TEM studies of pollen and its significance.

Module IV:

- Melissopalynology (Melittopalynology) - Pollen analysis of honey-methods, qualitative and quantitative, social organization of honey bees, foraging behavior, geographical and floral origin of honey, its chemical analysis, adulteration of honeys, physical characteristics of honey, deterioration of honey, heavy metal contamination in honey, honey as environmental monitors, unifloral and multifloral honey, Applied Melissopalynology -Role in Agriculture/ Horticulture : Bees as pollinators, role of apiaries in crop 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.

(The above-mentioned topics should be taught in the light of the recent developments in the field)

Suggested readings:

Agashe S. N. – Paleobotany (1997) – Plants of the past their evolution paleoenvironment and applications in exploration of Fossil.

Agashe S. N. – Palynology and its Applications – Oxford and IBH Publishing Co. Pvt. Ltd. NewDelhi.

Agashe S. N. and Eric Caulton (2009) Pollen and Spores: Applications with Special Emphasis on Aerobiology and Allergy, CRC Press

Baker, H.G. 1954. Aperture membranes in Studies of Pollen Morphology and Taxonomy. Newphytologist,54(3),

Banerjee, U.C. 1965,et al. Exine plasticity during pollen grain maturation. J.palynol.:70-89,

Banerjee, U.C.1967.Ultrastructureof the tapetal membranes in grasses. Grana paIynologia: 7,2-3,

Bhattacharya K., Majumdar M. and Gupta Bhattacharya S. (2006). A textbook of Palynology. New Central Book Agency(P) Ltd.,Kolkata

Bhojwani, S .S. and S.P. Bhatnagar. 1978. The Embryology of Angiosperms. Vikas Publishing House, New Delhi,

Bir Bahadur 1998. Nectary biology. Datt Sons publications, Nagpur Bombay,

Bradley, D. E. 1958. The study of pollen grain surfaces in the electron microscope

New Phytologist Volume57, Issue2 : 226-229

Brooks. J. and G. Sha'w. 1978. Sporopollenin: A review of its chemistry, palaeochemistry and Geochemistry. Grana.17(2) :91-98.

Cresti, M., Gori P., Pacini E. (eds.) (1988) Sexual reproduction in higher plants. Springer, Berlin Heidelberg New YorkTokyo.

Cronquist, A. 1968. The evolution and classification of flowering plants, Nelson, London

Dafni Amots, Hesser Michel, Paeini Ettore – Pollen and Pollination-Springer Wien New York

Davis. P.H. and V.H. Heywood. 1963. Principles of Angiosperm Taxonomy. Oliver and Boyd, London,

Doyle James A(2005) Early evolution of angiosperm pollen as inferred from molecular and morphological phylogenetic analyses, Grana, 44:4, 227-251, DOI: 10.1080/00173130500424557

EI-Gazzar and M.K. Hamza. 1973. Morphology of the twin Pollinia of Asclepiadaceae. Pollen et spores XV(3-4)

Erdtman, G. 1943. An Introduction to Pollen Analysis. Chronica Botanica Co., Waltham, Mass. pp.239.

Erdtman, G. 1945. Pollen Morphology and Plant Taxonomy IV Labiatae, Verbenaceae, Avicenniaceae. Svensk Botanisk Tidskrift.39(3),p. 42.

Erdtman, G. 1945. Pollen morphology and plant taxonomy. V. On the occurrence of tetrads and dyads. Svensk Botanisk Tidskrift 39: 286 -297.

Erdtman, G. 1952. Pollen Morphology and Plant Taxonomy (An Introduction to Palynology-1, Angiosperms). Aimqvist, and Wicksell,Stockholm,

Erdtman, G. 1956. Current Trends in Palynological Research Work Grana Palynologica (N.S.)1:2,

Erdtman, G. 1960. The Acetolysis method revised description. Svensk Botanisk Tidskrift, 54, 561-564.

Erdtman, G. 1964. Palynology. In: W.B. Turrill (Editor) Vistas in Botany. Macmillan Go., New York, Vol.4:23-54.

Erdtman, G. (1966). Pollen morphology and plant taxonomy angiosperms Hafner. New York.

Erdtman, G. (1969). Handbook of Palynology. Hafner, NewYork

Faegri, K. 1975.(3rd Revised Ed.) Textbook of Pollen Analysis. Blackwell Scientific Publ. Oxford,

Heslop-Harrison, J. 1962.Origin of Exine. Nature, 195 (4846):1069-1071

Heslop-Harrison, J. 1976. The adaptive significance of the exine. Academic Press. London, Linn. Soc. Symp. Ser1:27-37,

Hyde, H.A. anrl D, A. Williams. 1945. 'Palynology', Nature. . 155-265, London

Iwanami, Y,, Sasakuma, T., Yamada, Y. (1988). Pollen: illustrations and scanning electron micrographs. Kodansha (Tokyo) and Springer, Berlin Heidelberg New York Tokyo

Knox,R.B., Singh, M.B. (1987). New perspectives in pollen biology and fertilization. Ann. Bot. Suppl.4:15-37.

Lieux. M. H. Acetolysis applied to .microscopical honey analysis. Grana 19: 57-61. uppsaia 26 hiarch 1980. ISSN 0017-3134.

Maheshwari, P, 1978. An Introduction to the Embryology of Angiosperms, Tata McGraw- Hill Publ. Co. New Delhi

P.K.K. Nair 1965 Trends in the morphological evolution of pollen and spores. J. Ind. Bot. Soc. Vol.44 : 468-478.pdf

Nair, P.K.K. 1966.Essentials of Palynology. Asia Publ. House, Bombay,

Nair, P.K.K-. 1970.Pollen morphology of Angiosperms. Scholar Publ. House, Lucknow,

Nair. P.K.K. 1965.Pollen Grains of Western Himalayan Plants. Asia Publ. House of pollen Vedams Book (P) Ltd. New Delhi.

Plummer, D.T (1987), An introduction to practical biochemistry (3rd edn). MeGraw-Hill.London (Tata Mc-Graw-Hill Edition,1988).

Praglowski, J. 1971. Reticulate and allied exines.Grana,11(2):79-86.

Rangaswamy, N.S. (1977) Application of in Vitro Pollination and in Vitro Fertilization. In: Reinert, J. and Bajaj, Y.P.S., Eds., Applied and Fundamental Aspects of Plant Cell Tissue, and Organ Culture, Springer, Berlin, 412-425.

Rowley, J.R. 1967. Fibrils, microtubules and lamellae in Pollen grains. Rev. Palaeobotan. Palynol. 3 :213-226,

Saad, S.I. 1963.Sporoderm Stratification: The Medine. a distinct third layer in the pollen wall. Pollen et spores. 5: 17-38

Shivanna, K.R. and Johri, B M 1989. The Angiosperm Pollen: Structure and Function. Wiley Eastern Ltd., NewDelhi

Shivanna, K.R. and Rangaswami, N.S. 1992. Pollen Biology: A laboratory manual. Narosa Publishing House, NewDelhi..

Skvarla, John J.; Rowley, John R.; and Chissoe, William F. (1988) "Adaptability of Scanning Electron Microscopy to Studies of Pollen Morphology," Aliso: A Journal of Systematic and Evolutionary Botany: Vol. 12: Iss. 1, Article 13, pp 119-175.

Sowunmi, M. A. 1976. The potential value of honey in palaeopalynology and archaeology. Rev. Palaeobot. palynol. 21: 171-185.

Sporne, K.R. 1972. Some observations on the evolution of pollen types in dicotyledons. Newphytol.71:181-185.

Swamy, B.G.L. and K.V. Krishnamurthy. 1980 From Flower to Fruit. Tata McGraw-Hill Publisher,

Thanikaimoni, G. (1978). Pollen morphological terms proposed definition-I ln Proc. IV Int. Palynol. Conf, Lucknow, Vol. 1, pp.228-239.

Van, Campo, M. et al. 1966-67. Suppl. Electron microscopy's contribution to the Knowledge of the structure of acetolysed pollen grains, I. Palyn Bull. II and III

Vishnu-Mittre. 1964. Contemporary thought in Palynology. Phytomolphology. 14(l): 101.

Vorwohl, G. 1967. The microscopic analysis of honey, a comparison of its methods with those of the other branches of palynology. - Rev. Palaeobot. Palynol. 3: 287-290

Walker, J.W. and J.A. Doyle. 1975. The basis of angiosperm phylogeny: Palynology. Ann. Missouri. Bot. Gard, 62: 664-723,

Walton, John. 1940. An Introduction to the Study of Fossil Plants. Adam and Charles Black, London

Wodehouse, R. P. 1935.Pollen Grains. McGraw Hill and Co. New York.

Practicals Based on Elective

Lab-5: DSC: MBO3P05: Palynology

Objectives:

- To get hands-on experience in the laboratory techniques used in a specialized branch of Botany.
- To sensitize the student with the methods used to collect the data, analyses it and present in form of tables, charts etc.
- To train the student in writing the report.

Outcomes

- The student is trained in the lab techniques used in a specialized branch of Botany.
- The student presents the data in various forms and prepares the report.

List of Practicals:

<u>Section A:</u> Basic aspects / Pollen Morphology (At least FIVE experiments)

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.
9. 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.)
10. Preparation and palynological description in technical language (at least 10 species of Angiosperms).
11. Interpretation of selected electron micrographs (SEM, TEM) of pollen.
12. Preparation, description and identification of spores of Algae, Fungi, Bryophytes, Pteridophytes and pollen types of Gymnosperms.

<u>Section B:</u> Aeropalynology / Melissopalynology (Melittopalynology) / Palaeopalynology (At least two experiments)

13. Use of pollen traps to study local air-spora.
14. Analysis of aerospora slides.
15. Preparation of reference slides by different techniques, culture method (culture of fungi/Algae)
16. Preparation of slides honey samples

17. Analysis of honey samples for qualitative and quantitative study of pollen contents.
18. Estimation of pollen load from beehive or bees/pollinator
19. Analysis of coal samples for microfossils with special reference to pollen and spores.
20. Preparation of allergenic extract of pollen.

<u>Section C:</u> Pollen Physiology/ecology/biochemistry/ecology. (At least three experiments)

21. To study pollen production of the given flowers.
22. To study pollen viability of the given flowers.
23. To study percentage of pollen germination & rate of pollen tube growth.
24. To study different techniques of pollen storage
25. Effect of temperature and relative humidity on viability of stored pollen
26. Effect on Boron and Calcium on pollen germination and tube growth.
27. Semi-vivo technique to study pollen germination and pollen tube growth.
28. Multiple staining for localizing pollen tubes in the pistil
29. To study pollen germination and pollen tube growth in the pistil by employing aniline-blue fluorescence method
30. Cytochemical localization of esterase on stigma surfaces
31. 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)
32. Study of pollen contents by paper chromatography/TLC.
33. Colorimetric estimation of proteins/carbohydrates of pollen grains
34. To separate pollen proteins by SDS-PAGE electrophoresis
35. Enzyme bioassay in pollen grains.

SEMESTER-III

Lab 5 (MBO3P05): Elective: Palynology

Section-A: SEE (50 Marks)

Time: 6 Hours **Full Marks: 50**

Q. 1. Pollen preparation by standard method/s – Section 'A'.	10
Q. 2. Any ONE experiment from Section 'B'.	10
Q. 3. Any ONE experiment from Section 'C'.	10
Q. 4. Any ONE experiment from Section A/B/C (Minor) (Other than asked in Question 1 – 3)	05
Q. 5. Spotting (E, F, G, H & I)	15

Section-B: CIE (50 Marks)

INTERNAL **Full Marks: 50**

Q. 1 Viva-voce.	20
Q. 2 Practical record.	10
Q. 3 Tour Report / Permeant Micro-Preparations / Herbarium Records / Field Diary / Industrial Visit / Laboratory Visit / Collection, Preservation & Culturing of Materials / Excursion Report (Wherever applicable)	20

Elective Paper: DSC: MB03T11: Ethnobotany-I

Objectives:

- To explore the medicinal plants.
- To study the ethnobotanical knowledge.
- To study the commercial values of medicinal plants.
- To study the scarcity, emergency, supplementary food, methodology and documentation and preparation.

Outcomes:

- The students employ the knowledge of ethnobotany.
- Students will able to collect and identify medicinal plants.
- Students explore the general principles of ethnobotany, including its history and importance in traditional and modern culture.

Module I:

- Ethnobotany: Definition, brief history, its aim, scope, and importance.
- Social aspects and interdisciplinary approaches.
- Ethnobotanical contribution of Vidarbha region of Maharashtra.
- Ethnic groups of India: Major and minor tribes.
- Major World centers of ethnobotanical studies.
- Contribution of renowned Ethnobotanists J. W. Harshberger, R E. Schultes, S. K. Jain and E. K. Janaki Ammal.

Module II:

- History and principles of Ayurveda, unani, siddha and homeopathy system of medicines.
- A general idea of active principles of plants and plant parts their extraction and preparation of medicines in different systems (tulsi, neem, bottle gourd).
- Scope and uses of secondary metabolites from plants as perfumes, cosmetics and as flavoring agents.
- Preparation of perfumes from aromatic plants with special reference to the following- lemon grass, palm-rosa, lavender, rose, Eucalyptus and vetiver.

Module III:

- Regional relevance and credibility of medicinal plants used by tribals of Maharashtra state.

- Customs and traditions followed by major tribes of Vidarbha
- Plants used in scarcity, emergency and supplementary foods by tribals of India.
- Methodology and documentation of ethnobotanical research.
- Role of ethnobotany in conservation and sustainable development.

Module IV:

- Plants used in medicine with special reference to following: *Boerhaavia diffusa, Eclipta prostrata, Psoralea corylifolia, Withania sominifera, Tylophora indica, Rauwolfia serpentina, Justicia adhatoda, Asparagus racemosus, Tinospora cordifolia, Terminalia arjuna, Terminalia bellerica, Terminalia chebula, Pterocarpus marsupium.*

(The above-mentioned topics should be taught in the light of the recent developments in the field)

Note:- 1. Short excursion tour/visit is expected.

Suggested readings:

Ambasta, S. P. (Ed.) (1986). The useful plants of India, Publications and information Direxorate, CSIR, New Delhi.

Chaudhari Rai, H. N., Banerjee, P. K., Guha, A. 1977, Ethnobotanical uses of herbaria, Bull. Bot. Surv. India.

Cotton, C. M. (1996), Ethnobotany: principles and applications, John Willey and Sons, England.

Cunnigham, A. (2001), Applied Ethnobotany: People wild plant use and conservation, Earthscan, UK.

Ethnic Tribes and medicinal plants: edited by Pravin Chandra Trivedi, pointer Pub. 2010, xii, 264p. ICBN – 9788171326235

Ford, R. I. (ed. 1978, the nature and status of ethnobotany. Anthropological papersno.67. Museum of Athrop., Univ. of Michigan.

Harshberger, J. W. (1896), ethnobotany: Principles and Applications, John Willey & Sons, Chichester, New York.

Harshberger, J. W. 1896. The purpose of ethnobotany, Bot. Gazette 31:146-154. Jain, S. K. and Rao, R. R. 1983. Ethnobotany in India. An overview botanical survey of India.

Jain, S. K. (1987), A manual of Ethnobotany, Indus Intl. Publishers, New Delhi.

Jain, S. K. (1989), Methods and approaches in Ethnobotany. Society of Ethnobotanist, Lucknow.

Jain, S. K. (2001), Medicinal plants, National Book Trust, India.

Jain, S. K. (2003), Medicinal plants, National Book Trust, New Delhi (India)

Jain, S. K. and Mudgal, V. (1999), A hand Book of Ethnobotany, Bishen Singh Mahendrapal Singh, Dehradun.

Joshi, S.G. (2000), Medicinal plants, oxford and IBH Publishing Co. Pvt. Ltd., New Delhi.

Kokate, C. K., Gokhale, A. S. and Gokhale, S. B. (2006), cultivation of medicinal plants, 3rd ed., Nirali Prakashan, Pune, M.S.

Maheshwari, J. K. Ed. (2000), ethnobotany and medicinal plants of Indian subcontinent, scientific, publishers, Jodhpur.

Martin, G. J. (2004), Ethnobotany: A methods manuals, Earthscan, UK.

Martin, J. G. 2000, Ethnobotany: A methods manual, Chapman and Hall, USA.

Mukherjee, P. K. and Houghton, P. J. (2009), evaluation of herbal medicinal products, published by pharmaceutical press, London

Nautiyal, S. and Kaul, A. K. 2003, Non-timber forest products of India, Jyoti Pub. Dehradun.

Shrivastava, A. K. (2006), Medicial plants, AP II Publishing Corporation, New Delhi.

Trivedi, P. C. 2006, Medicinal plants: Ethnobotanical Approach, Agrobios, India.

Wood, M. (1997), The Book of Herbal wisdom: using plants as medicines, North Atlantic Books, California.

Practicals Based on Elective

Lab-5: DSC: MBO3P05: Ethnobotany

List of Practicals:

1. Description, identification and uses of medicinal plants.
2. Photography of medicinal plants of local area.
3. Ethnoveterinary medicines from local plants.
4. Herbal preparation of
   (i) Extract of Tulsi leaves
   (ii) Rose water
   (iii) Beverage of Tulsi, Bel, Mango
   (iv) Ayurvedic Tea
   (v) Tablet of amla vati
   (vi) Murabba of Awla, Bel
   (vii) Herbal dye

(viii) Ointment from neem leaves

(ix) Ayurvedic tooth powder

(x) Face pack from herbs

(xi) Triphala churn

(xii) Herbal shampoo

5. To cultivate at least two medicinal plant in earthen pot.

6. Field study of ethnobotanical importance of forest area/tribal area/local area.

SEMESTER-III

Lab 5 (MBO3P05): Elective: Ethnobotany

Section-A: SEE (50 Marks)

Time: 6 Hours **Full Marks: 50**

Q.1 To prepare a herbal formulation from the given material (A). 15

Q.2 To perform phytochemical tests of the given medicinal plant (B). 15

Q.3 To describe and identify the given material and comment on its medicinal properties (C). 10

Q.4 Comments on the spots: 10

(D) Bark/stem

(E) Leaves

(F) Roots

(G) Plant

(H) Seeds

Section-B: CIE (50 Marks)

INTERNAL **Full Marks: 50**

Q. 1 Viva-voce. 20

Q. 2 Practical record. 10

Q. 3 Tour Report / Permeant Micro-Preparations / Herbarium Records / Field Diary / Industrial Visit / Laboratory Visit / Collection, Preservation & Culturing of Materials / Excursion Report (Wherever applicable) 20

Elective Paper: DSC: MB03T11: Advanced Phycology and Hydrobiology-I

Objectives:

- To understand the salient features and economic importance of algal diversity.
- To study the structure and reproduction of various genera mentioned in the field of lower plants.
- To familiarize the salient features and economic importance of various algal groups.

Outcomes:

- Understand the contributions of famous Indian phycologists and centers of Algal Research in India.
- Understand the classificatory approaches and advances in algal taxonomy.
- Understand the general features of algae and its different groups and their representative genera.
- Study their ecological and economic importance.

Module I:

- Prokaryotic characters, ultra structure of cell, reproduction and affinities.
- Sources of Nitrogen and its assimilation, importance and activity of biofertilizers, biotechnological implication and Biological Nitrogen fixation.
- Biotechnology and international market, Nif gene transformation and present status of genetic engineering.
- Toxic algae: Phycotoxins, characteristics and their effects on human beings.
- Algae cytology and genetics.
- Calcification, extracellular products of algae and fossil algae.

Module II:

- **Bacteria:** Strain selection, sterilization, growth, fermentation production, application technology for major biofertilizers, viz. *Rhizobium, Azotobacter, Azospirillum, Bacillus megaterium*(PSB), *and Pseudomonas fluorescens.*
- **Cyanobacteria:***Phormidium, Aulosira, Cylindrospermum, Rivularia*; Symbiotic algae and their role in other plants.

Module III:

- Algae as a food, feed and medicine.

- Eukaryotic characters (morphology) reproduction, life cycle patterns, taxonomy, Phylogeny and interrelationship of Protochlorophyta, Chlorophyta, Charophyta, Xanthophyta, Bacillariophyta, Pheophyta and Rhodophyta.
- Prochlorophyta: *Prochloron*.
- Chlorophyta: *Microspora, Draparnaldia, Trentopholia, Fritschiella, Cosmarium, Codium, Bryopsis.*

Module IV:

- Phaeophyta: Thallus range, cell structure, alternation of generation, *Cutleria, Padina, Laminaria, Turbinaria.*
- Rhodophyta*: Nemalion, Gelidium, Gracilaria, Corallina, Polysiphonia*.
- Euglenophyta: *Euglena, Phacus*.
- Bacillariophyta: *Cyclotella, Synedra, Cymbella, Navicula, Gomphonema.*
- Chrysophyta: *Synura and Dinobryon.*
- Industrial product from algae.

Suggested Readings:

Fritsch, F.E. 1979. The structure and Reproduction of Algae Vol. I & II. Bishan Singh, Mahendra Pal Singh, Dehradun.

Kumar, H.D. 1988. Introductory Phycology: Affiliated East-West Press Ltd. N. Delhi.

Morris, I. 1986. An introduction of Algae. Cambridge University Press U.K.

Prescott, G.W. 1984. Algae: A review, Bishan Singh, Mahendra Pal Singh. Dehradun.

Fritsch, F.E. 1977. Structure and Reproduction of Algae. Vol. I & II. Vikash Publishing House Pvt. Ltd. New Delhi.

Trainer, F.R. 1978. Introductory Phycology. John. Wiley and Son: Inc.

Round, F.E. 1984. Ecology of Algae. Academic. Press. London.

Tilden, J.F. 1968. The Algae and their Life Relations. Hafner Publishing Co. New York.

H.C. Bold and MJ. Wynne. 1978. Introduction to the Algae. Prentice Hall of India. Pvt. Ltd. New Delhi. 10. Smith, G.M. 1957. Manual of Phycology. The Ronald Press Company. New York.

Venkataraman, G.S., S.K. Goyal. B.D. Kaushik and P. Roy. Choudhary. 1974. Algae: Form and Function. Today and Tomorrow. Print. And Publication. New Delhi.

Round, F.E. 1965. The Biology of the Algae, Edward Arnold. Ltd. London.

Desikachary, T.V.1984. Cyanophyta. ICAR, New Delhi.

Fogg, F. Blue Green Algae. Bishan Singh, Mahendra Pal Singh, Dehradun.

Madigan, M.T., J.M. Martink and J. Parker (1997). Brock Biology of Microorganism. Printice hall International, Inc., New, Jersey.

Prescott (2000). Microbiology.

Cruezer, W. and A. Cruezer (1990). A Textbook of Industrial Microbiology.

Alexander, M. (1977). Soil Microbiology. John Wiley and Sons, New York.

Dubey, R.C. and D.K. Maheshwari (2010). A Textbook of Microbiology. S. Chand and Co. Pvt. Ltd. New Delhi.

Khapekar R. R. Essentials of Limnology, Preface Book & Co., Nagpur.

Practicals Based on Elective

Lab-5: DSC: MBO3P05: Advanced Phycology & Hydrobiology-I

List of Practicals:

1. **Bacteria:** *Rhizobium, Azotobacter, Azospirillum, Bacillus megaterium*(PSB), *and Pseudomonas fluorescens.*
2. Local collection of different algae forms and their study.
3. **Cyanobacteria:***Phormidium, Aulosira, Cylindrospermum, Rivularia*
4. **Algae**
   a) Chlorophyta: *Microspora, Draparnaldia, Trentopholia, Fritschiella, Cosmarium, Codium, Bryopsis.*
   b) Phaeophyta:*Cutleria, Padina, Laminaria, Turbinaria.*
   c) Rhodophyta :*Nemalion, Gelidium, Gracilaria, Corallina, Polysiphonia*.
   d) Euglenophyta: *Euglena, Phacus*.
   e) Bacillariophyta: *Cyclotella, Synedra, Cymbella, Navicula, Gomphonema.*
   f) Chrysophyta: *Synura and Dinobryon*
5. Separation of algal pigments
6. Extraction and separation of amino acids and carbohydrates
7. Determine the density of phytoplankton.
8. Analysis of water samples for Dissolved Oxygen, pH & Temperature, Free Carbon dioxide, Total alkalinity, Total Hardness, Calcium Hardness, BOD & COD, Chloride, Ammonical Nitrogen.
9. Analysis of soil for Chloride, Phosphate, Nitrogen, Calcium, Magnesium.

10. Isolation and Culturing of fresh water Algal forms in Laboratory.
11. Cultivation of microalgae using photo bioreactor or in pilot pond systems.
12. Algae oil extraction by mechanical and chemical methods (Solvents/Soxhlet extraction).

SEMESTER-III

Lab 5 (MBO3P05): Elective: Advanced Phycology & Hydrobiology-I

Section-A: SEE (50 Marks)

Time: 6 Hours **Full Marks: 50**

Q. 1. Isolation and identification of Two Prokaryotes (Bacteria & Cyanobacteria) (A).	10
Q. 2. Isolation and identification of Two Eukaryotes (B).	10
Q. 3. To perform given Experiments (C).	10
Q. 4. To analyse the water samples for given test (D).	05
Q. 5. To analyse the soil samples for given test (E).	05
Q. 6. To isolate the given algal sample and identify (F).	06
Q. 7. Identify the spots giving reasons G, H.	04

Section-B: CIE (50 Marks)

INTERNAL **Full Marks: 50**

Q. 1 Viva-voce.	20
Q. 2 Practical record.	10
Q. 3 Tour Report / Permeant Micro-Preparations / Herbarium Records / Field Diary / Industrial Visit / Laboratory Visit / Collection, Preservation & Culturing of Materials / Excursion Report (Wherever applicable)	20

M.Sc. Botany (NEP-2020)

Semester IV

Mandatory Paper: DSC: MBO4T12: Angiosperm-II

Objectives:

- To study the rules of plant nomenclature and technique of plant identification.
- To study the origin of Angiosperms and characters of a few important families.
- To study the distribution of plant species with respect to the geographical factors.

Outcomes

- Understand the basic principles of plant systematics, including identification, nomenclature and classification.
- The student traces the phylogeny of angiosperms with the probable ancestors and develop an insight to correlate the characters and interpret to decipher the evolutionary riddles.
- The student realizes the floristic wealth of the world and appreciates the commercial importance of plants
- The student correlates the geographical factors with the development of vegetation and distribution of plants.

Module I:

Plant Nomenclature

- Brief history on the origin and development of nomenclature; International Code of Nomenclature for algae, fungi and plants (ICN); Effective and valid publications; Rank of taxa; Rules of priority and its limitations; Typifications; Author's citation; Rejection of names; Retention of names; Conserved names; Nomenclature of hybrids; Brief account of International Code of Nomenclature of cultivated plants (ICNCP). Molecular Systematics Plant genomes; Generating molecular data (gene mapping, gene sequencing, analysis of molecular data); Molecular characters (chloroplast DNA, rbcL, rRNA, VNTR).

Module II:

- Families of Angiosperms Characteristic features, inter-relationship, economic importance and classification as per APG IV system of the following groups and families. ANITA grade: Amborellaceae, Illiciaceae, Nymphaeaceae Magnoliids- Magnoliales (Magnoliaceae), Ranunculales (Ranunclaceae) Monocots- Alismitales (Araceae), Poales (Poaceae) Commeliniids- Arecales (Arecaceae) Eudicots (Tricolpates)- Caryophyllales (Amaranthaceae) Fabids- Fabales (Fabaceae (Leguminosae), Cucurbitales (Cucurbitaceae) Malvids- Malvales (Malvaceae) Asterids- Lamiids- Lamiales (Acanthaceae), Campanuliids- Asterales (Asteraceae), Apiales (Apiaceae)

Module III:

- **Origin of Angiosperms:** The first traces of Angiosperms; Early Cretaceous (Sanmiguelia) and Upper Cretaceous (Prisca) Angiosperms; Probable ancestors of angiosperms (Isoetes–Monocotyledon theory, Caytonialean theory, Stachyospory– Phyllospermae theory, Pteridosperm theory, Coniferales Amentiferae theory, Genetales– angiosperm theory, Pentoxylales theory, Durian theory); Origin of monocots; Insects and evolution of angiosperm; Cradle of angiosperms; Evolutionary trends in Angiosperms.

Module IV:

- **Phytogeography -** Phytogeographic regions of the world, general characters of the flora of India (Eastern India, Western India, the Indus plain, the Gangetic plain, Malabar, the Deccan, Assam, Andaman & Nicobar island); Continental drift, types and areas of Natural distribution; Endemism and endemic areas, continuous and inter-continental ranges, discontinuous ranges, vicarious areas; Centre of origin of crop plants; Geographical classification of families; Cosmopolitan and very wide species; Endemic species.

(The above-mentioned topics should be taught in the light of the recent developments in the field)

Suggested readings

Devis, P.H. and Heywood, V. H. 1973 Principles of angiosperms taxonomy. Robert E. Kreiger Pub. Co. Newyork.

Grant W. F. 1984 Plant Biosystematics. Academic press, London. Grant, V. 1971 Plant Speciation, Columbia University press, London.

Gurcharan Singh 2022 Plant systematics: An integrated approach 4e. Routledge, USA.

Harisson, H.J. 1971 New concept in flowering plant Taxonomy. Hickman educational books Ltd. London.

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

Hislop-Harisson, J. 1967 Plant Taxonomy. English Language Book Sco.And Edward Arnold Pub.Ltd, UK.

Joncs, A. D. and Wibins, A. D. 1971 Variation and adaptation in Plant species Hickman and Co. New York.

Joncs, A. D. and Wibins, A. D. 1971 Variation and adaptation in Plant species Hickman and Co. Jones,

S. B., Jr.and Luchsinger, A. E. 1986 Plant Systematics (gd edition). McGraw-Hill Book Co., New Delhi.

Jones, S. B., Jr.and Luchsinger, A. E. 1986 Plant Systematics. McGraw-Hill Book Co., New York.

Nordentam, B., El Gazaly, G. and kassas, M. 2000 Plant systematic for 2ft century. Portlant press.Ltd, London.

Radford, A. E. 1986 Fundamentals of plant systematics.

Harper and Raw publication, USA. Solbrig, O.T. 1970 Principles and methods of plant Sytematics. The Macmillan Co. Publication Co. Inc., USA.

Stebbins, G. L. 1974 Flowering Plants-evolution Above species Level. Edvard Arnold Ltd, London.

Takhtajan, A. L. 1997 Diversity and classification of Flowering Plants. Columbia University Press, New York.

Woodland, D. W. 1991 Contemporary Plant Syatematics, Pentice Hall, New Jersery.

Recent issues of the relevant ‘Annual Reviews’ should also be consulted.

Mandatory Paper: DSC: MBO4T13: Molecular Biology

Objectives:

- To give the student in-depth information on the gene structure, and the mechanism & regulation of gene expression.
- To update the student on the aspects of cell cycle and its regulation.
- To appraise the student on the mechanisms evolved by the plants and other organisms to communicate with the environment.
- To give a comprehensive idea to the student on recombination and mapping of genes in viruses, bacteria and eukaryotes.
- To introduce the student to the major techniques used in molecular biology research.

Outcomes

- The student appreciates the significance of gene expression, cell cycle and signal transduction in the life of a plant and other organisms.
- The student takes a stance to employ the knowledge of the mechanism and regulation of gene expression, cell cycle and signal transduction to mitigate the stress and apply it for the benefit of humans using appropriate tools.
- The student is equipped with skill to map the genes in viruses, bacteria and eukaryotes.

Module I:

a. **Gene structure:** Classical concept of the gene: Beads-on-string concept, Oliver's experiment with lozenge locus of Drosophila melanogaster; Fine structure of gene: Position effect (Sturtevant's experiment on Bar locus), Benzer's experiment on rII locus of T4 phage, Complex loci, cis- trans test & its application, gene-cistron equivalence; Multigene families: Globin gene family and Immunoglobulin gene family.

b. **Transcription:** Flow of genetic information through the cell; The process: Transcription in bacteria, transcription & RNA processing in eukaryotic cells (including alternative splicing), promoters and transcription factors; Synthesis and processing of rRNAs and tRNAs; Synthesis and processing of mRNAs: Transcription machinery, split genes, processing of eukaryotic mRNA, evolutionary implications of split genes and RNA splicing; Non-coding RNAs.

c. **Genetic code:** Encoding genetic information: Properties of genetic code, identifying the codons; Decoding the codons: Structure of tRNAs, Wobble hypothesis, amino acid activation.

Module II:

a. **Translation:** *Ribosomes:* Structure of 70S and 80S ribosomes; Protein biosynthesis in prokaryotes (bacteria) and eukaryotes: Initiation, elongation, termination, mRNA surveillance and quality control, polyribosomes; Regulation of cytosolic protein biosynthesis in eukaryotes; Protein synthesis in chloroplasts and its regulation; Post-translational modification: Proteolytic processing, protein folding & localisation; Protein degradation: Significance, role of protease, ubiquitin and N-terminus.

b. **Protein sorting:** Targeting domain(s); Protein targeting to: Plastids, mitochondria, peroxisomes and nucleus; Role of ER in protein sorting and assembly: Protein movement in secretory system, role of topogenic sequences, protein modification, transport between ER and GC; Vacuolar targeting and secretion; Protein modification in GC: Glycosylation, movement between Golgi cisternae.

c. **Regulation of gene expression:**

In Prokaryotes (Bacteria): Bacterial operons, positive and negative control, inducible and repressible operons, *lac* operon and its control, *trp* operon and its control through attenuation & TRAP mediation, bacterial enhancers, antisense RNA, riboswitches, ribozymes.

In Eukaryotes: Regulation at DNA level (DNA amplification, programmed DNA arrangement, epigenetic mechanism & chromatin remodeling); Regulation at transcription level (Protein-DNA interaction, hormonal regulation, enhancers, silencers, alternative splicing, mRNA stability, RNA interference & transcriptional stalling); Regulation at translational and post translational level.

Module III:

a. **Recombination:** Introduction to recombination; independent assortment and crossing over. *Types of recombination:* Homologous, non-homologous, site-specific, transposition and copy choice. *Homologous recombination during meiosis:* Double strand breakage and reunion, synaptonemal complex. Bacterial RecBCD pathway. RecA pathway. Role of Ruv complex. Gene conversion. Site-specific recombination.

b. **Phage genome & its gene mapping:** Bacteriophage genome, Crossing the phages, genetic recombination in phage, determination of recombination frequency and gene mapping.

c. **Bacterial genome & its gene mapping:** Introduction, Mapping of bacterial genes through transformation, conjugation and transduction.

d. **Gene mapping in eukaryotes:** Introduction to genetic markers, DNA markers, physical markers. *Genetic maps (linkage maps):* Detection of linkage, concept of genetic map, two-point test cross, three-point test cross, calculating accurate map distances (mapping functions), correlation between map distance and physical distance. *Physical maps:* Restriction mapping and STS mapping. Somatic cell genetics-an alternative approach to gene mapping.

Module IV:

a. **Cell cycle and apoptosis:** Introduction; Bacterial cell cycle (Helmsetter and Cooper model) and its control; Eukaryotic cell cycle: Overview, check point control, presence of regulators of cell cycle (experiment involving cell fusion), G1–S progression, G2–M progression, regulation of kinases, role of phosphorylation and dephosphorylation, role of Cdc2 in yeasts, alteration of S and M phases, control of animal cell cycle, role of cyclins and cyclin dependent kinases, role of cdk inhibitors, protein degradation and mitosis; Cytokinesis and cell plate formation; Apoptosis and its pathway.

b. **Signal transduction:** Introduction; Types of signal transduction (activation of kinases and G-proteins); Termination of signaling; Ligands and receptors: Criteria of a receptor, receptors (GPCRs, RTKs, ligand- gated channels & steroid hormone receptor); Phosphorylation cascades; Specific examples: Ras/MAPK pathway, JAK-STAT pathway, TGFβ signaling, G-proteins & phospholipid signaling; Role of cyclic nucleotides; Calcium-calmodulin cascades; Two-component sensor- regulator system in bacteria and plants (perception of ethylene, cytokinin, *Arabidopsis* response regulators).

c. **Techniques in cell biology:** Electrophoresis: Principle, factors affecting the mobility, types of electrophoresis (paper, cellulose acetate, gel), procedure and applications; ELISA: Principle, Indirect method, sandwich method, practical considerations and applications; Western blotting: Principle, procedure and applications; Southern blotting: Principle, procedure and applications; FISH: Principle, procedure and applications; GISH: Principle, procedure and applications; Confocal microscopy: Principle, resolution, types of confocal microscopes, 3-D imaging & real-time imaging.

(The above-mentioned topics should be taught in the light of the recent developments in the field)

Suggested readings

Alberts, B., Bray, D., Lewis, J., Raff, M., Roberts, K. and Watson, J.D. (1999) Molecular biology of the cell (third edition); Garland Publishing, New York and London.

Alberts, B., Johnson, A., Lewis, J., Morgan, D., Raff, M., Roberts, K. and Walter, P. (2015) Molecular Biology of the cell 6e. Garland Science, Taylor and Francis Group, UK.

Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K. and Walter, P. (2002). Molecular Biology of the Cell, 4th edition. Garland Publishing, Inc., New York.

Brown, T.A. (2007). Genomes 3. Garland Science Publishing, USA.

Brown, T.A. (2016). Gene cloning and DNA analysis: An introduction 7e. Wiley-Blackwell, UK.

Buchanan, B.B., Gruissem, W., Jones, R.L. (2015). Biochemistry and Molecular Biology of plants. American Soc. of Plant Physiologists, Maryland, USA.

Cooper, G.M. and Hausman, R.E. (2007). The cell: A molecular approach 4e. Sinauer Associates Inc., USA.

Dale, J.W. and Von-Schantz, M. (2007). From genes to genomes 2e. John Wiley and Sons Ltd., England.

De Robertis, E.D.P. and De Robertis, E.M.F. (1987). Cell and Molecular Biology 8th Ed. B. I. Waverly Pvt. Ltd., New Delhi, India.

Hexter, W. and Yost Jr., H.T. (1977). The Science of Genetics. Prentice Hall of India Pvt. Ltd.

Jones, R., Ougham, H., Thomas, H. and Waaland, S. (2013). The Molecular life of plants. Wiley-Blackwell, USA.

Karp, G. (1999). Cells and Molecular Biology; Concepts and Experiments. John Wiley & Sons, Inc., USA.

Karp, G. (2016). Cell and Molecular Biology: Concepts and Experiments 8th Ed. John Wiley & Sons, Inc., USA.

Khush, G.S. (1973). Cytogenetics of Aneuploids. Academic Press, New York, London.

Kleinsmith, L.J. and Kish, V.M. (1995). Principles of Cell and Molecular Biology 2e. Harper Collins College Publisher, USA.

Kleinsmith, L.J. and Kish, V.M. (1995). Principles of Cell and Molecular Biology (2nd Edi.) Harper Collins Coll. Publisher, New York, USA.

Lewin, B. (2000). Gene VII. Oxford Univ. Press, New York.

Lewin, B. (2004). Genes VIII. Pearson Prentice Hall, USA.

Lodish, H., Berk, A., Zipursky, S.L., Matsudaira, P., Baltimore, D. and Darnell, J. (2018). Molecular Cell Biology 6e. W. H. Freeman and Company, USA.

Malacinski, G. M. and Freifelder, D. (1998). Essentials of Molecular Biology (3rd Edi.) Jones and Bartiet Pub. Inc., London.

Pawley JB 2006 Handbook of Biological confocal microscopy 3e. Springer, USA. Upadhyay A, Upadhyay K, Nath N 2009 Biophysical chemistry. Himalaya Publishing House,

Russel, P. J. 1998 Genetics (5th Edi.) The Banjamin/ Cummings Publishing Com. Inc., USA.

Sunstad, D. P. and Simmons, M. J. (2000). Principles of Genetics (2nd Edi.) John Wiley & Sons Inc., USA.

Tamarin, R. H. (2001). Principles of Genetics 7th Edi. The McGraw-Hill Companies.

Watson, J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M. and Losic, R. (2009). Molecular Biology of the gene 5e. Pearson, India.

Wolf, S.L. (1993). Molecular and Cellular Biology. Wadsworth Publishing Co., California, USA.

References: Online journals available on UGC V-SAT programme

Mandatory Paper: DSC: MBTO4T14: Plant Biotechnology & Plant Breeding

Objectives:

- Understanding the principles and techniques of gene cloning, types of vectors.
- Knowledge on recombinant DNA technology & its tools, microbial genetic manipulations.
- To introduce the student with the fundamentals and techniques used for the production of transgenic plants.
- To give a comprehensive information on the technique of plant tissue culture to the student.
- Understanding the basic concepts of tissue culture and knowledge on transgenics.
- Practical knowledge and analysis skills in usage of various bioinformatic tools.
- To appraise the student about the theory and technique of plant breeding.

Outcomes:

- Learn gene cloning, recombinant DNA technology etc.
- The student is equipped with skills to isolate the gene, identify its function and transfer it to the suitable host.
- The student develops the expertise to *in vitro* cultivation of plants.
- culture the plants in vitro.
- Learn and apply bioinformatic tools for analysis of bioinformation data.
- The student is skilled with the basic know-how required for crop improvement.

Module I:

a. **Recombinant DNA technology:** Gene cloning - Principles and technique; *Tools for rDNA technology*: Restriction enzymes used in gene cloning i.e. DNA manipulation enzymes (nucleases, polymerases, ligases, kinases and phosphatases used in rDNA technology); Vectors: Concept of vectors rDNA technology, properties of ideal vector, cloning and expression vectors and their structural features, vectors types (Plasmid, Viral, Cosmid, Artificial Chromosome Vectors) & their properties; Splicing of insert into the vector; Host Cells (Prokaryotic & Eukaryotic) and properties of ideal host (in context with rDNA technology); Transformation of the bacterial host by Calcium chloride method and electroporation; Construction of DNA libraries (gDNA and cDNA) & screening of DNA libraries.
b. **Genetic engineering of plants:** Aims and applications of plant genetic engineering; *Gene constructs:* A typical plant gene, plant promoters (constitutive, tissue-specific, inducible, synthetic), reporter (marker) genes (scorable and selectable); Plant transformation vectors:

Agrobacterium plasmid vectors - pTi and pRi, T-DNA, *vir* region, concept of binary vector system; plant virus vectors (CaMV, Gemini viruses, TMV, BMV).

Module II:

a. **Genetic engineering of plants cont…** Plant transformation: *Agrobacterium* - the natural genetic engineer, Molecular mechanism of T-DNA transfer; *Indirect gene transfer:* Agrobacterium mediated plant transformation (Agro-infection and Co-cultivation, selection of transformed explants); *In-planta* transformation strategy; *Direct gene transfer:* Particle bombardment (Gene gun), Electroporation, Microinjection, Macroinjection, PEG; Confirmation of gene integration and its expression, gene stability check by inheritance studies. Introduction to Chloroplast transformation (vectors, markers, methods, advantages, limitations). Introduction to CRISPER-Cas9 technology (History, Principal & Applications). Salient achievements in crop biotechnology.
b. Genomics and Proteomics: Molecular markers for introgression of useful traits; *DNA synthesis* - Phosphoramidite method, assembling oligonucleotides into genes, application; *DNA sequencing* - Maxam and Gilbert's method, Sanger and Coulson method, pyrosequencing, application; High throughput sequencing; Basics of Next Generation Sequencing; Functional genomics; Protein profiling and its significance; Basics of polymerase chain reaction, variations in PCR & applications of PCR.

Module III:

a. **Plant tissue culture:** Basic concepts; Principles and scope; Basics of sterilization techniques used; Plant tissue culture media, importance of all ingredients in culture media; Callus culture & suspension culture; Concept of morphogenesis; Micropropagation & Multiple shoot induction; Organ culture; Protoplast Culture & Somatic Hybridization; Production of cybrids; Production of haploids & triploids; Somaclonal variations; Production of somatic embryos; Applications of plant tissue culture.

Module IV:

a. **Bioinformatics:** Introduction, History, Definition and applications of bioinformatics; Database: Sequences (nucleotide and amino acid); IUPAC symbols, nomenclature of DNA & protein sequences, directionality of sequences, types of sequences used in bioinformatics; Definitions & types and classification of databases - Primary Databases, Secondary databases, Literature database and Taxonomy database.

b. Introduction; Objectives of plant breeding; Methods of breeding self-pollinated crops: Introduction, selection (mass and pure line), hybridisation (pedigree, bulk, modified bulk, single seed descent, back-cross), mutation breeding; Methods of breeding cross-pollinated crops: Introduction, selection (inbred line, mass, recurrent), hybridisation (techniques-single cross, double cross, top cross, synthetics and composites; handling of the population-pedigree, bulk, modified method, single seed descent, back-cross), mutation breeding, ploidy breeding; Methods of breeding vegetatively propagated crops: Flowerless or sterile (clonal selection, mutation breeding), apomicts, flowers but seed-set rare (clonal selection, mutation breeding, hybridisation), Normal seed-set but propagated vegetatively (clonal selection, mother plant selection, mutation breeding, hybridisation); Male sterility: Types and role in plant breeding; Hybrid seed production: Scheme of hybridisation- based on choice of parents and choice of mating system, technique- pollen control, pollination, raising of F1 plants, subsequent procedure; Heterosis and inbreeding depression: Introduction, consequences of inbreeding, genetic basis.

(The above-mentioned topics should be taught in the light of the recent developments in the field)

Suggested readings

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.

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, John-Wiley and Sons Publications, New York.

Bhojwani, S.S. 1990 Plant tissue culture: Applications and limitations. Elsevier, Germany. Bhojwani SS, Razdan MK 1996 Plant tissue culture: Theory and Practice 1e. Elsevier Science. Brown TA 2007 Genomes 3. Garland Science Publishing, USA.

Brown, T. A. (1999). Genomes, John Wiley &Sons(Asia) Pvt. Ltd., Singapore.

Brown, T.A. (2016). Gene cloning and DNA analysis: An introduction 7e. Wiley-Blackwell, UK. Chopra VL 2000 Plant breeding: Theory and practice 2e. Oxford and IBH, India.

Callow, J. A., Ford-Lloyed, B. V. and Newbury, H. J. (1997). Biotechnology and Plant Genetic Resources: Conservation and Use, CAB International, Oxon UK.

Chrispeeels, M. J. and Sadava, D. E. (1994). Plants, Genes and Agriculture.Jones & Barlett Publishers, Boston, USA.

Dale, J.W. and Von-Schantz, M. (2007). From genes to genomes 2e. John Wiley and Sons Ltd., England. Dubey RC 2014 Advanced Biotechnology. S. Chand & Co. Pvt. Ltd., India.

Dubey, R. C. (2014). Advanced Biotechnology. S. Chand & Co. Pvt. Ltd., New Delhi.

Gamborg, O.L. and Phillips, G.C. (1995). Plant cell, tissue and organ culture: Fundamental methods.

Glazer, A. N. and Nikaido, H. (1995). Microbial Biotechnology. W. H. Freeman & Company, New York, USA.

Glick, B.R. and Patten, C.L. (2017). Molecular Biotechnology: Principles and applications of recombinant DNA. ASM press, USA.

Gustafson, R. J. (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.

Kingsman, S. M. Genetic Engineering: An Introduction to Gene Analysis and Exploitation in Eukaryotes, Blackwell Scientific Publications, Oxford, 1998

Mount W. (2004). Bioinformatics and sequence genome analysis 2nd Edi. CBS Pub. New Delhi

Narayanswamy, S. (1994). Plant cell and tissue culture. Tata McGraw-Hill Publ. Co., India.

Narosa Publ. House, India.

Old, R. W. and Primrose, S. B. (1989). Principles of Genome Analysis. Blackwell Scientific Publications. Oxford, UK.

Primrose, S. B. (1995). Principles of Genome Analysis. Blackwell Scientific Ltd., Oxford, UK.

Primrose, S.B. and Twyman, R.M. (2006). Principles of gene manipulations 7e. Wiley-Blackwell, USA. Sensen CW 2002 Essentials of Genomics and Bioinformatics. Wiley-VCH, Germany.

Raghavan, V. (1997). Molecular Biology of Flowering Plants. Cambridge University Press, New York, USA.

Singh, B.D. (2003). Biotechnology: Expanding horizons. Kalyani Publishers, India.

Stoskop, N.C., Tomes, D.T. and Christie, B.R. (2017). Plant Breeding: Theory and Practice 3e. Scientific publishers, India.

Vasil, I.K. and Thorpe, T.A. (1994). Plant cell and tissue culture. Springer, Dordrecht.

Elective Paper: DSE: MBO4T15: Molecular Biology and Plant Biotechnology-II

Objectives

- To accentuate the theoretical knowledge and technical skill of the student for genetic modification of the plants.
- To equip the student with skills for in vitro culture of plants and molecular plant breeding.
- To update the student about current progress in the field of environmental biotechnology to mitigate environmental pollution.

Outcomes

- The student is ready to explore the arena of genetic intervention for crop improvement and environment protection.
- The student is equipped with the technical know-how of plant tissue culture for crop improvement and plant conservation.

Module I:

- ***Transgenic plants-*** Gene transfer to plant cells: Plant transformation with the Ti plasmid of *Agrobacterium tumefaciens*, Ti plasmid-derived vector systems, direct gene transfer (electroporation, microinjection, microinjection, liposomes); Chloroplast engineering: Introduction, high level protein expression; Use of reporter genes in transformed plant cells; Manipulation of gene expression in plants: Transient gene expression, plant promoters, targeted gene editing, facilitating protein purification, protein glycosylation; Production of marker-free transgenic plants: Removing marker genes from nuclear DNA, removing marker genes from chloroplast DNA.

Module II:

- ***Use of rDNA technology to confer resistance to crops-*** Insect resistance: Genes coding for (Bt toxin, protease inhibitors, α-amylase inhibitor, cholesterol oxidase), Use of RNAi (Gossypol, flavr savr), preventing development of Bt-resistant insects; Targeting aphids; Virus resistance: Viral coat-mediated protection, protection by expression of other genes (single-chain antibodies, micro-RNAs, CRISPR-Cas); Herbicide resistance; Fungal resistance; Bacterial resistance; Salt and drought stress.
- ***Use of rDNA technology for quality improvement of crops-*** Delaying the flower wilting and fruit ripening; Modification of plant nutritional content: Aminoacids, lipids, vitamins,

iron, gluten; Modification of taste and appearance of the plant: Preventing discolouration, starch; Production of: Antibodies, PHB, edible vaccines; Altering lignin content; increasing oxygen content.

Module III:

Plant tissue culture

- History; Basic concept; Principle and scope;
- Culture media: Composition (mineral nutrition, pH, agar, plant growth regulators, vitamins, supplements, media formulated for plant tissue culture);
- Callus induction and cell suspension: Callus culture (introduction, callus initiation, dynamics of callus growth, subculture, metabolic patterns, growth measurements, habituation, somaclonal variation), cell suspension (introduction, culture media, growth measurements, single cell clones, large-scale culture, production of secondary metabolites, factors affecting the production of secondary metabolites);
- Haploid production: Androgenesis (anther culture, pollen culture, induction of non-haploids, diploidisation of haploids), gynogenesis, utilisation of haploids in agriculture;
- Somatic embryogenesis: General considerations, developmentpattern, factors influencing embryogenesis, effect of (PGRs, nitrogen source, other factors, genotype);
- Protoplast culture: Protoplast isolation, culture, somatic hybridisation (fusion,selection of hybrid cells, regeneration of hybrids, production of cybrids).

Module IV:

- **DNA fingerprinting -** Linkage analysis; RFLP maps; Characteristics, advantages and limitations of molecularmarkers used in DNA fingerprinting: RAPD, STS, SSR, ISSR, SCAR, SSCP, AFLP.
- **Molecular plant breeding -** Quantitative trait loci: QTL as hypothesis, QTL mapping; Map based cloning; Molecular marker assisted selection: Introduction, advantages, applications (gene introgression, gene pyramiding, development of heterotic hybrids).
- **Cleaner Biotechnology -** Introduction; Pollution control through genetically modified organisms: Bioremediation (introduction, use of GM microbes viz., *Pseudomonas* spp., *Rhodococcus* sp., *Burkholderia* spp.), phytoremediation (hyperaccumulators, use of GM plants viz., *Populus angustifolia, Nicotiana tabacum, Silene cucubalis, Brassica juncea*); Biofuels: Introduction, desirable features, disadvantages, Bioethanol (introduction, advantages, disadvantages, production fromvarious substrates, ethanol recovery), biodiesel

(introduction, production from various substrates), biohydrogen (advantages of hydrogen, production by anaerobic bacteria, photosynthetic algae, *in vitro* photosynthesis-hydrogenase system).

(The above-mentioned topics should be taught in the light of the recent developments in the field)

Suggested Reading

Books

Bhojwani SS 1990 Plant tissue culture: Applications and limitations. Elsevier, Germany. Bhojwani SS, Razdan MK 1996 Plant tissue culture: Theory and Practice 1e. Elsevier Science.Brown TA 2007 Genomes 3. Garland Science Publishing, USA.

Brown TA 2016 Gene cloning and DNA analysis: An introduction 7e. Wiley-Blackwell, UK. Chopra VL 2000 Plant breeding: Theory and practice 2e. Oxford and IBH, India.

Dale JW, von Schantz M 2007 From genes to genomes 2e. John Wiley and Sons Ltd., England. Gamborg OL, Phillips GC 1995 Plant cell, tissue and organ culture: Fundamental methods.

Narosa Publ. House, India.

Glick BR, Patten CL 2017 Molecular Biotechnology: Principles and applications of recombinant DNA. ASM press, USA.

Narayanswamy S 1994 Plant cell and tissue culture. Tata McGraw-Hill Publ. Co., India. Primrose SB, Twyman RM 2006 Principles of gene manipulations 7e. Wiley-Blackwell, USA.

Singh BD 2003 Biotechnology: Expanding horizons. Kalyani Publishers, India.

Singh RK, Singh R, Ye G, Selvi A, Rao GP 2010 Molecular plant breeding: Principle, method and application. Studium Press, USA.

Vasil IK, Thorpe TA 1994 Plant cell and tissue culture. Springer, Dordrecht.

Weising K, Nybom H, Wolff K, Kahl G 2005 DNA fingerprinting in plants: Principles, methods and applications 2e. CRC press, USA.

Review articles and Research papers

Biswas S, Zhang D, Shi J 2021 CRISPR/Cas systems: opportunities and challenges for crop breeding. Plant Cell Reports 40: 979-998. DoI: https://doi.org/10.1007/s00299-021-02708-2

Fulekar MH, Singh A, Bhaduri AM 2009 Genetic engineering strategies for enhancing phytoremediation of heavy metals. African Journal of Biotechnology 8(4): 529-535.

Kaul T, Sony SK, Verma R, Motelb KFA, Prakash AT, Eswaran M, Bharti J, Nehra M, Kaul R 2020 Revisiting CRISPR/Cas-mediated crop improvement: Special focus on nutrition.J. Biosci. 45: 137. DoI: 10.1007/s12038-020-00094-7

Kim S 2021 CRISPR innovations in plant breeding. Plant Cell Reports 40: 913-914. DoI: https://doi.org/10.1007/s00299-021-02703-7

Miladinovic D, Antunes D, Yildirim K, Bakhsh A, Cvejic S, Kondic-Spika A, Jeromela AM, Opsahl-Sorteberg H, Zambounis A, Hilioti Z 2021 Targeted plant improvement through genome editing: from laboratory to field. Plant Cell Reports 40: 935-951. DoI: https://doi.org/10.1007/s00299-020-02655-4

Wasilkowski D, Swedziol Z, Mrozik A 2012 The applicability of genetically modified microorganisms in bioremediation of contaminated environments. Chemik 66(8): 817-826.

Recent issues of the relevant ‘Annual Reviews’ should also be consulted.

Elective Paper: DSE: MBO4T15: Mycology and Plant Pathology- II

Objectives

- To study the fundamentals of plant pathology and the history of plant protection.
- To study the host-pathogen relationship in detail.
- To study the epidemiology of the important plant diseases caused by fungi, bacteria, viruses, phytoplasma and nematodes

Outcomes

- The student understands the principles of plant pathology.
- The student appreciates the contribution made by the persons and institutions to plant pathology.
- The student unravels the molecular mechanisms involved in pathogen attack and plant defence.
- The student is equipped with the knowledge of common diseases in plants, their spread and their control.

Module I:

- **History-** Milestones in phytopathology with particular reference to India; Major epidemics and their social impacts;
- **Effect of Environment on Disease Development-** Effect of Moisture, Temperature, Wind, Soil, pH and Host-plant nutrition.
- **Host defence mechanisms-** Structural defence, Hypersensivity, Physical barriers, Metabolic or Biochemcial defense, Phenols, Phytoalexins.
- Koch's Postulates.
- **Epidemiology** (Elements of epidemics, Measurement of Plant diseases, Patterns of epidemics and pathogens factors) and forecasting of plant diseases.
- **Indian Institutes** and their research activities in Mycology and Plant pathology.

Module II:

Principles of Plant pathology and Plant Disease Management.

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

- **Parasitism and Disease Development -** Host range of pathogens, disease development, disease cycle, penetration (chemical and physical), colonization and dissemination of pathogens.
- **Host Pathogen Interaction -** Chemical Weapons of pathogens (Enzymes, Toxins and Growth regulators).
- **Defence Mechanism in Host Plants Against Pathogens -** morphological or structural defence mechanism; Biochemical defence mechanisms- role of phenolic compounds, enzymes and toxins.
- **Principles & Methods of Plant Disease Control** - cultural methods, chemical methods, biological control, Physical Methods, transgenic approach for plant disease control, integrated pest management [(IPM: General account (importance and basic principles]., biopesticides.

Module III:

Plant tissue culture

A detailed study of the diseases of the following crops caused by fungal pathogens with effective control measures

- **Diseases Of Cereals -** a. Smut of wheat, b. Foot rot of wheat, c. Covered smut of Barley, d. False smut of rice, e. Downey mildew of jowar, f. Green ear disease of bajra,
- **Diseases Of Vegetable Crops -** a. Powdery mildew of Cucurbits; b. Leaf spot of Tomato; c. Chilli Die-back; d. Leaf spot of Tomato; e. Club root of Crucifers,.
- **Diseases Of Fruits & Vegetables -** General knowledge of post-harvest diseases and their control;
- **Diseases of Pulses and Oil Seeds -** Crops viz.,a. Pigeon pea Wilt; b. Chick pea Blight; c. Rust of Groundnut; d. Linseed Rust; e. Sunflower Rust.
- **Diseases of fruit-trees** with special reference to important diseases of the following: citrus, apple, mango, banana and grapes. a) Downy mildew of Grapes; b) Powdery mildew of grapes; c) Mango Anthracnose; d) Citrus Gummosis.

Module IV:

- **Bacterial Diseases of Plants:** a) Wildfire of Tobacco b) Wilt of Potato C) Angular leaf spot of Cotton d) Wilt of Tomato e) Soft rot and Scab of Potato
- **Plant Diseases Caused by Viruses & Viroids –** a) Bhendi vein clearing b) Papaya leaf curl c) Bunchy top of Banana d) Bud necrosis of Groundnut e) Bean common mosaic

- **Mycoplasma/Phytoplama (PPLO) Diseases of Plants –** a) Citrus greening b) Rice yellow dwarf c) Little leaf of brinjal d) Sandal spike.
- **Nematode Diseases of Plants -** General knowledge of plant parasitic nematodes and important nematode diseases viz., a. Root knot of vegetables, b. Ear cockle of wheat.

(The above-mentioned topics should be taught in the light of the recent developments in the field)

Suggested Reading

Agrios, G.N. (1980) Plant Pathology, academic Press, INC, New York. Ainsworth, G.C. and A.S.Sussman (eds). The Fungi, An advance Treatise Vol.I, II, III & IV Academic Press, New York.

Alexopoulos, C.J. (1962) Introductory Mycology. John Wiley Eastern Pvt. Ltd. Alexopoulos, C.J. and Mims C.W. (1979) Introductory Mycology 3rd Edition, John Wiley and Sons, Inc. Wiley, New York.

Alexopoulos, C.J., Mims and Black well (1996) 4th ed. John Wiley and Sons, Inc. Wiley, New York Aneja, K.R. (1993) Experimental in Microbiology, Plant Pathology & Tissue Culture, Wiswa Prakashan, New Delhi.

Barnett, J.H. (1968) Fundamentals of Mycology. The English Language Book Society and Edward Arnold Publication, Limited.

Bessey, E.A. (1950) Morphology and Taxonomy of Fungi. The Blakiston co. Philadelphia.

Bilgrami, K.S. and H.C.Dube (1985) A text Book of Modern Plant Pathology, Vikas Publication House, New Delhi.

Dube, R.C. and D.K.Maheshwari (1999) A.Text Book of microbiology, S.Chand & Co. Ltd. Dube,

Eggins, H.O.W. and Allsop (1975) The Filamentous Fungi Vol. I Industrial Mycology (Biodetoriation and Biodegradation by Fungi) Eds. J.E. Smith and D.R. Berry Edward Arnold, London.

Emmons, C. W., C. H. Bin ford, J.P. Utz and Know Chung (1977) Medical Mycology, Lea and Febigo, Philadelphia.

Gupta, V.K. and M.K.Behl (1994) Indian Plant Viruses and Mycoplasma Kalyani Publishers, Ludhiana. Jha, D.K. (1993) A Text Book of Seed Pathology, Vikas Publication House.

Holliday, P. Fungus disease of tropical plants (1980), Cambridge University Press, Cambridge. (Recent issues of the relevant 'Annual Reviews' should also be consulted).

M.J., Jr.Cahn, E.C.S. and N.R.Krieg (1993) Microbiology, Tata McGraw Hill. Preece and Dickeson. Ecology of leaf surface microorganism Academic Press, New York.

Mehrotra, R.S. (1989) Plant Pathology, Tata McGraw Hill.

Mehrotra, R.S. and K.R.Aneja (1998) An Introduction to Mycology, New Age Intermidiate Press. Pelzer.

R.C. and D.K.Maheshwari (2000) Practical Microbiology -S.Chand & Co. Ltd.

Rangaswamy, G. and A.Mahadevan (1999) Diseases of Crop Plant in India, Prentice Hall of India.

Raychoudhari, S.P. and Nariani, T.K. (1977) Virus and Mycoplasma Diseases of Plant in India, Oxford and IBH Publication Co.

Schlegel, H.G. (1996) General Microbiology, 7th Edition, Cambridge University Press.

Snowdon, A.L. (1991) A colour Atlas of Post harvest diseases & diso rders of fruits & vegetables Vol.I & II Wolfe Scientific, London.

Sunder Rajan, S. (2001) Tools and Techniques of Microbiology, Anmol Publ.New Delhi.

Thind, T.S. (1998) Diseases of field crops and their management, National Agricultural Technology, Information Centre, Ludhiana.

Vaidya, J.G. (1995) Biology of the fungi, Satyajeet Prakashan, Pune.

Walker, J.G. (1952) Diseases of Vegetables Crops. McGraw Hill, New York. Walker, J.C. (1968) Plant Pathology, McGraw Hill, New York.

Elective Paper: DSE: MBO4T15: Plant Physiology-II

Objectives

- Understanding the role of secondary metabolites in plants.
- Understanding various industrial applicable concepts and nanobiotechnology
- Understanding neuro and electro physiology
- Understanding the signal transduction in plant cells.

Outcomes

- Understand the importance of secondary metabolites and their medicinal importance
- Understand the applicability of learnt concepts at industrial level.
- Understand the pathways and proteins involved for different signaling response at cellular level.

Module I:

- **Secondary metabolites** – Introduction and classification, of secondary metabolites, their ecological functions in plants, Structure, biosynthesis, role in plants and applications of phenolic compounds, Alkaloids, Terpenoids, Glycosides, steroids and sterols, monoterpenes, limonene and carotene. Leaf protein: - Green crop fractionation (GCF), Leaf Protein Concentrate (LPC), Chloroplast, LPC, Cytoplasmic LPC, Deproteinized Leaf Juice (DPJ), Uses of DPJ. Importance of leaf Protein.

Module-II:

- **Plant Compounds & Drug Research And Discovery -** Methods of extraction, isolation, identification, characterization of active compounds present in medicinal plants. Qualitative and Quantitative analysis ofcompounds by using centrifuge, UV-Vis spectrophotometer, TLC, column chromatography, chromatography and mass spectrometry (HPTLC, HPLC, GC-MS, LC-MS, LC-MS/MS,), NMR, FT-IR, etc.,
- **Industrial Fermentation**, importance of fermentation, types of fermentation– alcohol fermentation, enzyme production, antibiotic production,
- **Biodiesel Production** - Introduction and historical account of biodiesel, methods of preparation biodiesel from vegetable oil, biochemical properties of biodiesel and Importance of biodiesel.

Module-III:

- **Plant Neuro/Electro Physiology - I**ntroduction and historical account of Plant electrophysiology, Factor affecting electrical potential, electrodes and methods used for Measuring the Electrical potential energy of plants and fruits.
- **Signal Perception and Transduction** - Introduction, overview of signal transduction pathway, receptors, specific examples of plant receptors, signal transduction in Prokaryotes, and eukaryotes, G-proteins and phospholipids signaling, cyclic nucleotides, secondary messengers (Calcium, calcium-calmodulin complexes, Protein kinases particular pathways of signal transduction Associated with plant growth regulators.

Module-IV:

- **Nanobiotechnology** - Definition, synthesis of green nano-particles, Synthetic andnatural bionanomaterials. biosensors and their applications, Applications of bionanoscience to materials research.
- **Vitamins and Antioxidants** - General characteristics, types and biochemical function role.
- **Phytoremediation** - General concept of phytoremediation, types of phytoremediation (phytoextraction, phytodegradation, phytostabilization, phytovolatilization, rhizodegradation, rhizofiltration), phytoremediation using terrestrial plants, phytoremediation of heavy metals, molecular mechanisms in the phytoremediation.

(The above-mentioned topics should be taught in the light of the recent developments in the field)

Suggested Reading

Asana, R.D. and Sarin M.N. (1968): Crop Physiology in India IARI Publ.

Abdelhamid Elaissari, (2008). Colloidal Nanoparticles in Biotechnology, John Wiley

Apps et al., (1992). Biochemistry, ELBS.

Atwll, B.J. Kriedcrmann, P.E. and Jumbull, C.G.N. (eds). 1999. Plants in action: Adaption in Nature Performance, in Cultivation, MacMillan Education.sydney, Australia.

Buchanan, B. B., Gruissem, W. and Jones, R.L. 1989. Biochemistry and Molecular Biology of plants. American Society of Plant Physiologists, Maryland, USA.

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

Charles PP and Frank JO, (2006). Introduction to Nanotechnology, Wiley India Ed.

Cherry, J. H. 1989. Environmental stresses in plants. biochemical and physiological mechanisms.

Conn E.E, Stumpf, Bruening G, Doi RH. (2005) . Outlines of Biochmistry 5/Ed, Wiley & Sons Pvt.ltd.

Caret et al., (1993). Inorganic, Organic and Biological Chemistry, WMC Brown Pub. USA.

Dey, P. M. And Harborne, J. B. 2000: Plant Biochemistry, Harcourt Asia PTE Ltd. A Harcourt Publishers International Company, 583 Orchard Road 09-01 Forum Singapore-238884.

Dennis, D.T., Turpin, D. H., Lefebvrc, D.D. and Layzell, D.B. (eds).1997. Plant Metabolism (2nd Ed.) Longman, Essex, England.

Evans, L.T. 1972. Crop physiology

Fageria, N. K. 1992. Maximizing crop yield.

Fertilizer association of India (1974): Fertilizer handbook of Usage.

Fitter, A. H. and Hay, R. K. M. S. (1987): Environmental Plant Physiology.

Gupta, U. S. (1972): Crop Physiology.

Gupta, I. S. (1986): Physiological aspects of dryland farming.

Gupta, U. S. (1975): Physiological aspects of dryland farming.

Gaiston, A.W.1989. Life Processes in Plants. Scientific American Library, Springer-Verlag, New York, USA.

Hans-Walter Heldt (2004). Plant Biochemistry. Elsevier Academic Press, 200-Wheeler Road, Burlington, MA 01803, USA, 525 B Street, Suite 1900, San Diego, California 92101-4495, USA

Hooykass P.J.J., Hall, M. A. and Libbenga, K.R. (eds).1999. Biochemistry and molecular Biology of plant Horm. Elsevier, Amsterdam, The Netherlands.

Hopkins, W.G. 1995. Introduction to Plant Physiology. John Wiley & Sons, Inc., New York, USA.

Hale, M.C. and Orcutt, D.M. (1987): The Physiology of Plants Under Stress. ICA handbook of Fertilizers.

Jain J.L. et al., (2008). Fundamentals of Biochemistry, Chand, New Delhi

Kozlowski, T. T. (1984): Flooding and Plant Growth. 11. Levitt, J. (1969, 1980): Responses of Plants to Environmental Stress.

Lodish, H., Berk, A., Zipursky S.L., Matsudaira, P., Baltimore, D and Darnell, J. 2000.

Molecular Cell Biology (4thed). W. H. Freeman and Company. New York, USA.

Moore, T.C. 1989. Biochemistry and Physiology of Plant Hormones (2nded). Springer- Verlag, New York, USA.

Mansfield, C.A. (1976): Effect of air pollutant on plants.

Marschner, H. W. (1986): Mineral nutrition of Higher Plants.

McLaren, J.S. (1985): Chemical manipulation of crop growth and Development.

Mehrotra, R.S. (1980): Plant Pathology.

Mahadevan, A and Sridhar R. (1986) Methods in Physiological plant Pathology, Sivakami Publications, Madras

Nobel, P.S.1999. Physicochemical and Environmental Plant Physiology (2nd ed). Academic Press, Diego, USA.

Nelson D.L, Cox M.M. (2005). Lehninger Principle of Biochemistry, W.H. freeman and Company, New York

Nickell, L.G. (1986): Plant growth regulators in Agriculture.

Pessarkli, M. (2004): Handbook of Plant and Crop Physiology, Marcel Dekkar Inc. NY.

Pessarkli, M. (2005): Handbook of Photosynthesis.

Pradeep T. (2007). NANO: The Essentials – Understanding Nanoscience and Nanotechnology, TATA McGraw – Hill Education.

Paleg, L.G. and Aspinal, D. (1982): The Physiology and Biochemistry of Drought resistant in Plants.

Pojakoff Mayber A. and Gale, J. (1975): Plants in saline environment.

Rawn, D. (1989). Biochemistry, Neil Patterson.

Ranjan, purohit, Prasad 2003: Plant Hormones Action and Application, Agrobios (India), agro house, behind Nasrani cinema Chopasani Road, Jodhpur -342002

Rice, E. L. (1982): Allelopathy (Physiological Ecology).

Raven, P.H., Evrt, R.F. and Eichhorn, S. 1992. Biology of Plants (5th edition). Worth, New York.

Rastogi, S.C (2003). Outlines of Biochemistry, CBS Publishers &Distributors , New Delhi

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

Steeves, T.A. and Sussex, I.M., 1989.Patterns in Plant Development (2nd edition).

Cambridge University Press, Cambridge.

Stryer, L., (1988). Biochemistry, WH Freeman & Co., NY.

Satyanaryana U, Chakrapaani U, (2006). Biochemistry, Books and Allied (P)Ltd.

Sharma, S. Raghavan, V. 1999.Developmental Biology of Flowering Plants. Springer-Verlag, New York.

Sinha S.K., Sane P.V., Bhargava S.C. and Agarwal P.K. (1990): Proceeding of International Congress of Plant Physiology Vol. I & II.

Salisbury, F.B. and Ross, C.W.1992: Plant Physiology (4thed). Wadsworth Publishing Co., California, USA.

Singhal G.S., Renger, G., Sopory, S.K., Irrgang, K.D. and Govindjee.1999: Concepts in Photobiol Photosynthesis and Photomorphogenesis. Narosa Publishing House, New Delhi.71

Turner, N. C. and Cramer, P.J. (1980): Adaptation of plants to water and high temperature stress.

Taiz, L. and Zeiger, E. 1998: Plant Physiology. Sinaucr Associates, Inc., Publishers, Massachus, USA.

Thomas, B. and Vince-Prue, D.1997: Photoperiodism in Plants (2nd ed).Academic Press, San Diego, USA.

Upeke, L. K. (1982): Tropical tree crops.

Westhoff, P.1998: Molecular Plant Development: From gene to plant. Oxford University Press, Oxford, UK.

Zuley G.L., (1998). Biochemistry, Wm.C. Brown Publishers USA.

Elective Paper: DSE: MBO4T15: Reproductive Biology of Angiosperms-II

Objectives

- To study the process of fertilization and embryo formation in Angiosperms in detail.
- To study the processes alternative to sexual reproduction and their implications in plants.
- To study the technique of plant tissue culture with special reference to experimental embryology.

Outcomes

- The student has a greater insight of the sexual and alternative processes of reproduction in Angiosperms.
- The student is equipped with the technical know-how of plant tissue culture.
- The student is able to explore the techniques of experimental embryology for commercial use and/or for conservation.

Module I:

Fertilization

- **Introduction -** Reduction in gametophyte is manifested, discussion (Stigma style, nature of stigma covering, function and structure of style, pollen germination pollen tube formation - all these aspects studied in Elective I i.e., Paper – XI Module IV) Background and study of all these aspects are necessary while studying fertilization.
- **Cellular nature of the sperm -** Sperm cytoskeleton, male germ unit, isolation and characterization of the sperm; Odyssey of the sperm and double fertilization: Growth of the pollen tube through the style, passage of the sperm into the embryo sac, growth through the filiform apparatus, entry into the synergid, transfer of the tube content, fusion of gamete, fusion of nuclei, double fertilization, triple fusion, in vitro fertilization and intra-ovarian pollination, test tube fertilization, in vitro fertilization, placental pollination, gynogenesis (the development of embryo from unfertilized female gametes).

Endosperm development

- **Introduction -** Types of endosperms - Nuclear, cellular, and helobial, wall formation in each type, histochemistry and ultrastructure in each type, ruminate endosperm, cytology and chemical composition; Nutritional role of endosperm; Endosperm haustoria; Reserve materials in developing endosperm (protein, starch, embryo-endosperm relationship, endosperm mutants).

Module-II:

Embryo development in Angiosperms [Embryogenesis]

- Historical account; Scope and definition of angiosperm embryology.
- Origin of Embryo: Status of egg, milieu of the egg (surrounding of the egg) zygote, ultrastructure of the zygote (Structural changes from egg to zygote), polarity in the zygote, rest period in the zygote; Embryonomic formulae: Application of the formulae on early embryogenesis (up to 4th cell generation); Stages leading to mature embryo.
- Classification of Embryo development based on early development: System suggested by Schnarf and Johansen, Soueges; Differentiation in embryo, dicot and monocot embryo, grass embryo and embryo in palms, cytochemical aspects,
- Suspensor: Structure and function (ultrastructure) cytology of suspensor cells, physiology and biochemistry of suspensor, Nutrition of the embryo.
- Deviation from the normal development of embryo: In Paeonia, Balanophoraceae, Orobanchaceae, Eriocaulaceae and Orchidaceae.
- Chimeral embryos: Genetic control of embryogenesis, storage protein synthesis in developing embryo.
- Polyembryony: Definition, causes, classification, induction of polyembryony, importance of polyembryony.

Module-III:

- **Apomixis and Parthenocarpy -** Apomixis: Introduction; Definition; Classification (Terminology); Synonyms in the terminology; Agamospermy; Adventitious embryony; Gametophytic apomixes: Diplospory apospory, pseudogamy, autonomous apomixis; Apomixis and sexuality; Causes and consequences of apomixes; Apomixis and polyploidy; Significance of apomixis; Parthenocarpy: Definition, causes, practical importance.
- **Biotechnology -** Concept and scope of Biotechnology; Experimental embryology, Techniques of cell, Tissue and organ culture; Anther and pollen culture; Nutritional requirements Pollen plants; Use of haploids; Ovary, ovule and nucellus culture; Endosperm culture; Organogenesis in endosperm culture; Embryo culture, control of embryogenesis, practical applications of embryo culture.

Module-IV:

- **Protoplast Culture -** Isolation of protoplast; Culture methods; Fusion of protoplast; Selection of fusion product; Consequences of fusion; Production of cybrids and hybrids, 'Pomatoes' and 'Topatoes'; Practical applications of protoplast culture.
- **Somatic Embryogenesis -** Introduction; Dynamics of somatic embryogenesis; Embryogenesis from callus; Direct somatic embryogenesis; Recurrent embryogenesis; Cell biology and physiology of somatic embryogenesis (Cytology of somatic embryogenesis, nutritional factors, hormonal factors. Biochemistry of somatic embryogenesis); Regulation of gene expression; Genetic analysis of somatic embryos; Cell culture; Application of cell culture, bioreactor, fermenter, auxotroph.

(The above-mentioned topics should be taught in the light of the recent developments in the field)

Suggested Reading

Bhojwani SS (1990) Plant tissue culture: Applications and limitations. Elsevier, Germany. Bhojwani SS, Razdan MK (1996) Plant tissue culture: Theory and Practice 1e. Elsevier.

Gamborg OL, Phillips GC (1995) Plant cell, tissue and organ culture: Fundamental methods. Narosa Publ. House, India.

Johri, B.M. (Ed) (1982) Experimental Embryology of vascular plants. Springer-Verlag, Berlin. Johri, B.M. (Ed.) (1984) Embryology of Angiosperms. Springer-Verlag, Berlin.

Narayanswamy S (1994) Plant cell and tissue culture. Tata McGraw-Hill Publ. Co., India. Nettancourt, de D. (1977) Incompatibility in Angiosperms. Springer-Verlag, Berlin.

Raghvan V. (1992) Developmental Biology of flowering plants, Springer-Verlag, Berlin. Raghvan V. (1997) Molecular Embryology of Flowering plants. Cambridge Uni. Press. Simpson, M.G. (2010) Plant systematics. Elsevier.

Vasil IK, Thorpe TA (1994) Plant cell and tissue culture. Springer, Dordrecht.

Recent issues of the relevant 'Annual Reviews' should also be consulted.

Elective Paper: DSE: MBO4T15: Palaeobotany-II

Objectives

- To study fossils to understand how plants have adapted to life on land and diversified over millions of years..
- To study the origins of modern plant diversity and the ecological dynamics of early terrestrial environments.
- To study the environmental changes, evolution of gymnosperms, and major radiations of seed plant lineages and to gain insights into the factors driving plant diversification and ecosystem dynamics.
- To study the origins, evolutionary processes, and environmental factors influencing the emergence and diversification of flowering plants (angiosperms), as well as related evolutionary trends and environmental changes.

Outcomes

- The student will understand that fossil evidence provides valuable insights into the evolutionary history of early land plants and the processes that led to their colonization of terrestrial environments.
- The student will gain knowledge about the evolutionary processes and environmental factors that led to the emergence of forests and the evolution of trees during Earth's history.
- The student will comprehend phylogenetic relationships, pale environmental data, will reconstruct past ecosystems and understand the evolutionary processes that shaped modern plant biodiversity.
- The student will acquire knowledge about the complex interplay between evolutionary processes and environmental dynamics in shaping the origin and evolution of flowering plants and associated vegetation communities over geological timescales.

Module I:

Earliest Forms of Plant Life

- Earliest Environments; Evidences for the Accumulation of organic material and Formation of ***first cell*** and the Geological evidence for the formation of ***first prokaryotes—*** Stromatolites, Cherts and Shales; Fossil bacteria in *Rhynie* Chert, Early Photosynthesis and Evidences for Evolution of ***eukaryotes—*** Geological evidence, Green algae (*Grypania,*

Cladophora), Red Algae (*Bangia*); Structural Comparisons of Earliest fossil eukaryotes and extant forms, Comparison at Molecular Level; **Colonization of Land-Environmental changes during Cambrian** and **Ordovician** (541-443Ma)— Formation of noticeable and stable environments near the shores, formation of soils, Development of suitable Climatic and Atmospheric conditions;

- **Fossil evidence for plant terrestrialization—** Reduction of Dependence on water for perpetuation (reproduction), Modification of Life Cycle, Protection against Desiccation, Evolution of Specialized cells supporting water and nutrient Uptake, Anchoring mechanism (Rhizoids and roots), Development of Mechanical support;
- **Earliest Land Plants in Fossil Records**—
- *Cooksonia Aglaophyton major (*Earlier *Rhynia major), Horneophyton, Rhynia gwynne-vaughanii, Zosterophyllum divaricatum* and Evolution of Lycophytes, *Baragwanathia longifolia, Psilophyton princeps, P. dawsonii*;
- **Evolutionary Trends:** Link between *Green algae to Land plants, Fossil Evidence, Evidence for evolutionary links between the green algae group Charales and Land plants* (*e.g., Coleochaetales* from Devonian localities, extant *Chara* and *Octochara gracillis, Palaeonitella*); **An Alternative View for the Greening of Land; Evolutionary Trends in Land Plants: *Non-vascular to Vascular*—** Plant fossil Evidence, Phylogenetic evidence for this transition [Bryophytes (Liverworts, Mosses and Hornworts) to Polysporangiophytes including *Aglaophyton, Horneophyton* clade and Trachaeophytes; Trachaeophytes divided in Rhyniopsida and Eutrachaeophytes; Eutrachaeophytes divided into Lycophytina (*Zosterophyllum* and *Baragwanathia*) and Euphylophytina (include 99% of extant vascular plant species, the fossil example being *Psilophyton* spp];

MODULE II:

The First Forests

- Environmental changes during **Mid Devonian** to the **end of Carboniferous** (~394 - 299Ma)— Glaciation in mid- to low latitudes, Enhanced Precipitation in Narrow Equatorial Belt, Drop in atmospheric Carbon dioxide upto 90% And Peak Atmospheric Oxygen levels;
- **Major Changes and Inovations in Plant fossil records along with Evidences of Plant Adaptations** during **Mid Devonian** to the **end of Carboniferous** (~394 - 299Ma)— Stelar

Evolution (Protostele, Siphonostele to Eustele), Additional Supporting Mechanisms like roots, roots stocks, rhizomes etc., thickening of stems, Leaves, Microphylls to Megaphylls (Enation Theory, Telome Theory); **Further Adaptations in plant Life Cycle**— *Evolution of Heterospory and Seed Habit :* Homospory (Isospores) to Heterospory followed by Evolution of Ovule, Evolution of Seed coat (testa-tegmen), Development of Mechanism to receive Pollen (Pollen chamber in Gymnosperms, stigma in Angiosperms) Heterospory to Pre-pollen to Pollen;

Earliest Trees in the Fossil records—

A) Spore-producing Trees

i. **Evolution of the Concept of Progymnosperms : Free-sporing** Plants with Gymnospermous Wood (Secondary Xylem) based on Organic connection between *Archaeopteris* leaf and *Callixylon* wood; Brief idea about the Aneurophytales, Archaeopteridales, and Protopitylaes; Evolutionary Significance of Progymnosperms with Relation to Seed plants;

ii. **Lycophytes—** Arborescent Tree genera like *Lepidodendron* spp, *Stigmaria Lepidophlois*, and *Sigillaria*;

iii. **Equisetophytes—** *Calamites* spp/ *Calamostachys* (different parts including fructifications)

iv. **Filicopsids (Ferns)—** *Psaronius /Botryopteris* (Comparison with *Pseudosporochnus* Trunk) and evolution of Marattiales,

v. Homosporous and heterosporous Herbaceous genera- Asteroxylon, *Sphenophyllum Azolla, Salvania, Marsilea*

B) Earliest Seed-producing Trees:

i. **Seed Ferns** (Palaeozoic **Pteridosperms**) — *Elkinsia polymorpha*, *Medullosa*; Evolutionary Relationship between Seed ferns and Seed plants;

ii. **Cordaites—** Vegetative Morphology and Reproductive structures; Evolutionary relationships between Cordaites and Conifers; **Vegetation Dynamics in Carboniferous.**

MODULE III:

Major Emergence of Seed Plants

a) Environmental Changes during **the Permian** (299-252Ma) involving Transition from the Carboniferous to Permian;

b) Evolution of Gymnosperms— Vegetative and Reproductive Structures, And Origin and Relationships of :i) cycads (Cycadales), ii) bennittites (Bennettittales / Cycadeoidales), ii) ginkgos (Ginkgoales), iv) glossoppterids (Glossopteridales) and v) gnetales (Gnetales);

Major Radiations of the conifers (**Coniferales**), and other Seed Plant Lineages (**Caytoniales**)—Vegetative and Reproductive Structures,Origin and Relationships of: Coniferales, Caytoniales and Evolutionary significance;

MODULE IV:

Flowering Plant Origins -Evidence for the First Angiosperms; Reasons for Late Emergence of Angiosperms— a) **Concept of Flowers and Floral whorls**; Brief idea abour Major Angiosperm Lineages and their Key-features (ANA group, Monocots, Ceratophyllales, Eudicots); Early Fossil Angiosperms like *Archaeanthus linnebergi* (Magnollid), Nymphaeales, *Archaefructus sinensis* (? Nymphaeales); b) Fruits and Seeds; c) Pollen; d) Leaves;

Nature and Distribution of the Earliest Angiosperms—a) Trees, Shrubs or Herbs **b)** Herbaceous or Aquatic; **c)** Place of origin and Rate of Radiation

Late Emergence of Angiosperms -a) Nature of the Fossil Evidence, b) Environmental Considerations, c) Biotic Interactions, d) Co-evolution of Insect and angiosperms

Evolutionary Trends— Gymnosperms to Angiosperms;

Environmental changes over the past 66 million years Coenozoic : (**Early Paleocene** to the **Pleistocene** (66Ma - 11 kyr)—a) Early Palaeocene to middle Eocene (66 – 50 Ma),

b) Middle Eocene to end Pliocene (~50 – 2.5Ma),c) The Pliocene (2.5 Ma to 11 kyr),

Evolution of Grasses—The First Grasses; Why so late Emergence of grasses

Decline of Forests and Spread of arid land Vegetation

Mass Extinctions and Persistent Populations-Meaning and Scope; Evidences from Plant and animal records; Mass extinction versus persistence in the plant fossil records and reasons for their persistence

Evolutionary Theories And Plant Fossil Records-Phyletic Gradualism (Darwin, 1859); Punctuated Equilibrium (Eldredge and Gould 1972); Brief idea of Mechanism of Evolutionary change.

(The above-mentioned topics should be taught in the light of the recent developments in the field)

Suggested reading

Agashe, S.N. (1995), Palaeobotany, Oxford & IBH, New Delhi

Arnold, C.A. (1947): Introduction to Palaeobotany, Mc-Graw Hill Book Co. Inc., New York and London.

Coulter J.M. & Chamberlain C.J. (1978): Morphology of Gymnosperms, Central Book Depot, Allahabad.

Christopher J. Cleal, Barry A. Thomas (2009) Introduction to Plant Fossils Cambridge Press

K.J. Willis, J.C. McElwain 2nd Ed (2014) The Evolution of Plants Oxford University Press

Eames, A.J. (1974): Morphology of Vascular Plants- lower groups, Tata Mc-Graw Hill publishing Co., New Delhi

Michael Krings, Carla J. Harper, Nestor Ruben Cuneo, Gar W. Rothwell (2018) Transformative Palaeobotany Academic Press (Elsevier)

P.C. Trivedi (2008) Palaeobotany to Modern Botany, Pointer Publications Jaipur Raj. India

Siddiqui, K.A. (2002) Elements of Palaeobotany, Kitab Mahal, Allahabad.

Spicer, R.A. & Thomas, B.A. (1986) Systematic and taxonomic approaches in Palaeobotany. Systematic Association Special Volume

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

Thomas, B.A. & Spicer R.A. (1987): The Evolution and Palaeobiology of land plants Discordies Press, Fortland, USA.

Thomas N. Taylor, Michael Krings, Edith L. Taylor (2015) Fossil Fungi Academic Press (Elsevier)

On line Journals available on UGC -VSAT

Elective Paper: DSE: MBO4T15: Palynology - II

Objectives

- To study various aspects of pollen physiology and biochemistry
- To study and understand the various aspects of pollen biotechnology, genetics, and forensic palynology.
- To get the knowledge on aerobiology history and various methods applied for collection and data analysis.
- To study the different airborne micro-biodata particularly pollen & spores, monitoring techniques, analysis
- To gain the knowledge on pollen allergy, causes, symptoms, prevention, and cure.

Outcomes

- To understand the different aspects of pollen physiology, biochemistry, genetics and biotechnology in order to understand the role of pollen in plant breeding experiments for developing new variety, germplasm conservation, disease resistant variety, increasing crop yield, production of haploids, use of recombinant DNA technology for crop improvement.
- To know about the scope of forensic palynology and its applications in in solving criminal investigations.
- To gain knowledge about the different aeroallergens, immunoglobulins, testing and treatment of allergies and will be aware about the preparation of standardization of allergens.
- To apply the knowledge of aerobiology in exploring airborne allergens, helping allergologists / physicians in proper diagnosis and treatment of allergies, in developing disease forecasting method of fungal crop pathogens and prevention of allergies in allergy patients.

Module I:

Pollen physiology and biochemistry-

- Pollen production, Pollen viability, techniques involved, Pollen germination -in *vivo* and in *vitro*, germination requirements, Role of boron and calcium in pollen germination, Factors affecting pollen germination. Chemical composition of pollen wall and pollen contents (amino acids, proteins, carbohydrates, lipids, vitamins, pectin, DNA, RNA, ascorbic acid, flavones, pigments etc.). 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, forensic palynology

- Pollen storage-Factors affecting viability in storage, freeze-drying of pollen, storage of pollen inorganic solvents, causes of decreased viability in storage and pollen germination.
- Pollen-pistil interaction- significance, self-incompatibility (regulation of fertilization) 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, examples

Module III:

- Aerobiology-Introduction, Historical background, applications of Aeropalynology, Aeromycology, Aerophycology. Importance in medical and Agricultural field, disease forecasting of crop plants, aerobiological work in India and abroad.
- Different devices to collect spores, pollen grains such as kite, balloons, air strips and slides, and other non-volumetric samplers, volumetric samplers, culturing techniques, analysis of data and their processing.
- Intramural (Indoor) and extramural (Outdoor) air-spora studies - identification & characteristics, seasonal changes of air-spora.

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, pollinosis, nasobroncheal allergy, Prevention and cure, Human immunoglobulins- types, and significance in diagnosis of allergy, diagnosing allergic diseases, Testing and treatment standardization, pollen calendar, Correlation between aerobiological, clinical and meteorological data.

(The above-mentioned topics should be taught in the light of the recent developments in the field)

Suggested Reading

Agashe S. N. – Paleobotany (1997) – Plants of the past their evolution paleoenvironment and applications in exploration of Fossil.

Agashe S. N. – Palynology and its Applications – Oxford and IBH Publishing Co. Pvt. Ltd. New Delhi.

Agashe S. N. and Eric Caulton (2009) Pollen and Spores: Applications with Special Emphasis on Aerobiology and Allergy, CRC Press

Alexander M.P. (1969). Differential staining of aborted and non-aborted pollen Stain Technol44:117-122.

Alexander, M.P. (1987). A method for staining pollen tubes in pistil. Stain Technol 62, 107-112.

Alexander MP, Ganeshan S. (1989) An improved cellophane method for in vitro germination of recalcitrant pollen. Stain Technol. Sep;64(5):225-7. doi: 10.3109/10520298909107005. PMID: 263341

Banerjee, U.C. 1965,et al. Exine plasticity during pollen grain maturation. J.palynol.:70-89,

Banerjee, U.C.1967.Ultrastructure of the tapetal membranes in grasses. Grana palynologia: 7: 2-3.

Bhattacharya K., Majumdar M. and Gupta Bhattacharya S. (2006). A text book of Palynology. New Central Book Agency(P) Ltd., Kolkata

Hague Joel P., Stephen L. Dellaporta, Maria A. Moreno, Chip Longo, Kimberly Nelson and Albert P. Kausch Pollen Sterility—A Promising Approach to Gene Confinement and Breeding for Genetically Modified Bioenergy Crops Agriculture 2012, 2, 295-315; doi:10.3390/agriculture204029

Erdtman, G. 1943. An Introduction to Pollen Analysis. Chronica Botanica Co., Waltham, Mass. pp.239.

Erdtman, G. 1945. Pollen morphology and plant taxonomy. V. On the occurrence of tetrads and dyads. Svensk Botanisk Tidskrift 39: 286 -297

Erdtman, G. 1952. Pollen Morphology and Plant Taxonomy (An Introduction to Palynology-1, Angiosperms). Aimqvist, and Wicksell, Stockholm,

Erdtman, G. 1956. Current Trends in Palynological Research Work Grana Palynologica

(N.S.)1:2,

Erdtman, G. 1964. Palynology. In: W.B. Turrill (Editor) Vistas in Botany. Macmillan Go., New York, Vol.4:23-54.

Erdtman, G. (1969). Handbook of Palynology. Hafner, NewYork

Faegri, K. 1975.(3rd Revised Ed.) Textbook of Pollen Analysis. Blackwell ScientificPubl. Oxford,

Heslop-Harrison, J. (1987). Pollen germination and pollen tube growth. Int. Rev. Cytol. 107:1-78.

Heslop-Harrison, J. 1971. (Editor). Pollen: Development & Physiology. Butterworths, London,

Shivanna K.R. (1984). The evaluation of pollen quality and a further appraisal of the fluorochromatic (FCR) test procedure. Theor. Appl. Genet 67:367-375.

Hyde, H.A. anrl D, A. Williams. 1945. 'Palynology', Nature. . 155-265,London

Jain A., Shivanna, K.R. (1988a). Storage of pollen grains in organic solvents: effect of organic solvents on ieaching of phospholipids and its relationship to pollen viability. Ann. Bot. 61:325-330

Jain A., Shivanna, K.R. (1988b). Storage of pollen grains in organic solvents. Effects of solvents on pollen viability and membrane integrity. J. Plant Physiol.132:499-502.

Jain A., Shivanna, K.R. (1989). Loss of viability during storage is associated with changes in membrane phospholipid. Phytochemistry 28:999-1002.

Knox, R.B., Singh, M.B. (1987). New perspectives in pollen biology and fertilization. Ann. Bot. Suppl.4:15-37.

Knox. R.B., Williams, E.G., Dumas, C. (1986). Pollen, pistil, and reproductive function in crop plants.Plant Breed.Rev.4:9-79.

Levings C S , D.R. Pring,1979. 5 - Molecular Bases of Cytoplasmic Male Sterility in Maize Physiological Genetics Pages 171-193, DOI https://doi.org/10.1016/C2013-0-11457-2

Maheshwari, P, 1978. An Introduction to the Embryology of Angiosperms, Tata McGraw- Hill Publ. Co. NewDelhi.

Mildenhall, D.C, Patricia E.J. Wiltshire and Vaughn M Bryant. 2006. Forensic palynology: Why do it and how it works (Editorial) Forensic Science International 163 : 163–172

Nair, P.K.K. 1966.Essentials of Palynology. Asia Publ. House,Bombay,

Nair, P.K.K-. 1970.Pollen morphology of Angiosperms. Scholar Publ. House,Lucknow,

Nair. P.K.K. 1965.Pollen Grains of Western Himalayan Plants.Asia Publ. House.of pollen vedamse Book (P) Ltd. NewDelhi.

Plummer, D.T (1987), An introduction to practical biochemistry (3rd edn). MeGraw-Hill.London (Tata Mc-Graw-Hill Edition,1988).

Rangaswamy, N.S. (1977). Applications of in vitro pollination and in vitro fertilization. In.. Reinert J., Bajaj. YPS (eds.). Applied and fundamental aspects of plant cell tissue and organ culture. Springer, Berling, Heidelberg. New York, pp.412425.

Rowley, J.R. 1967. Fibrils, microtubules and lamellae in Pollen grains. Rev. Palaeobotan. Palynol. 3:213-226,

ShiD.-Q. and W.-C. Yang 2010. Pollen Germination and Tube Growth Plant Developmental Biology - Biotechnological Perspectives: Volume 1, Page 245-282 Pua, Eng Chong; Davey, Michael R. (Eds.) Springer-Verlag Berlin Heidelberg

Shivanna, K, R. (1982,). Pollen-pistil-interaction and control of fertilization. In: Johri B.M. (ed.). Experimental embryology of vascular plants. Springer, Berlin Heidelberg New York, pp, 131-174.

Shivanna, K.R. and Johri, B M 1989. The Angiosperm Pollen: Structure and Function. Wiley Eastern Ltd., NewDelhi

Shivanna, K.R. and Rangaswami, N.S. 1992. Pollen Biology: A laboratory manual. Narosa Publishing House, NewDelhi..

Stanley, R.G. and H.F. Linskens. 1974. Pollen. Biology, Biochemistry management, Springer-Verlag,Berlin,

Stanley, R.G., Linskens, H.F. (1974). Pollen: biology. Biochemistry and management. Springer, Berlin Heidelberg New York.

Steer, M.W, Steer, J.M. (1989). Pollen tube tip growth. New Phytol.111:323-358

Talde U.K. 1994.Advances in Mycology and Aerobiology-Dr S T Tilak commemoration volume.

Tilak S.T. 1982. Aerobiology, Vaijayanti Prakashan,Aurangabad

Tilak S.T.1989. Recent researches in Ecology, Environment and Pollution. Today & Tomorrow Pub., NewDelhi

Tilak S.T. 1987 “Air monitoring practical Manual”, Vaijayanti Prakashan,Aurangabad.

Tilak S.T. 2009. Aeromycology. Bharati Printing Press,Pune.

Tilak S. T. 1989. Atlas of airborne pollen grains and fungal spores. Vaijayanti Prakashan, Aurangabad.

Tilak S. T. 1989. Env.Ecology and Aerobiology.Today & Tomorrow.s Printers, New Delhi.

Vishnu-Mittre. 1964.Contemporary thought in Palynology. Phytomorphology. 14(l): 101.

of angiosperm phylogeny: Palynology. Ann. Missouri. Bot. Gard, 62. 664-723,

Walker, M. A. 2013. Entomology and Palynology (Solving Crimes with Science: Forensics). Mason Crest Publishers. ISBN13 978-1422228661.

Wodehouse,R.P.1935.PollenGrains.McGrawHillandCo.NewYork.

Yadav Mohith S (2022) Current Trends in Forensic Palynology. In j Fore Res, 3(1), 100-103. ISSN: 2767-2972.

Elective Paper: DSE: MBO4T15: Ethnobotany - II

Objectives

- To explore the identification and utilization of medicinal plants.
- To study the herbal remedies, toxicity, herbal medicinal products, finger printing, IPR and patents.
- To study the adulteration and deterioration of herbal drugs, ethnopharmacology, bioprospecting, reverse pharmacology and role of ethnobotany.
- To study the analytical profile and biological screening of herbal drugs and in vivo and in vitro techniques of ailments.

Outcomes

- The students employ the knowledge of identification and utilization of medicinal plants.
- Students will able to understand the adulteration and deterioration of herbal drugs, ethnopharmacology, bioprospecting, reverse pharmacology and role of ethnobotany.
- Students explore the analytical profile and biological screening of herbal drugs and in vivo and in vitro techniques of ailments.

Module I:

- **Plant parts used as powder:** Identification and Utilization of Amla (*Emblica officinalis*), Garlic (*Allium sativum*), Ashwagandha (*Withania somnifera*), Turmeric (*Curcuma longa*), Cinnamon (*Cinnamomum verum*).
- **Plant parts used as decoction:** Identification and Utilization of Bottle gourd (*Lagenaria siceraria*), Neem (*Azadirachta indica*), Onion (*Allium cepa*), Bael (*Aegle marmelos*), Basil (*Ocimum spp.*).
- **Plant parts used as lotion and ointments:** Identification and Utilization of Korphad (*Aloe vera*), fenugreek (*Trigonella foenum graecum*).
- **Plant parts used as oil:** Identification and Utilization of Clove (*Syzygium aromaticum*), Coconut (*Cocos nucifera*), Nilgiri (*Eucalyptus spp.*).
- **Plant parts used as dressings:** Identification and Utilization of Cotton (*Gossypium spp.*), Jute (*Corchorus spp.*), Banana (*Musa paradisiaca*).
- **Plant parts used as poultice:** Identification and Utilization of Dhotra (*Datura spp*), Erandi (*Ricinus communis*).

Module II:

- Herbal Drugs: remedies, toxicity and regulations for drug administrations.
- Efficacy of herbal medicine products and validation of herbal therapies.
- Phytochemical finger printing HPTLC and LCMS/GCMS applications in the characterization of herbal extracts.
- Relevance of IPR in Ethnobotany; Patents: Indian and international patent laws, proposed amendments as applicable to herbal/natural products and process.

Module III:

- Adulteration and deterioration of herbal drugs: introduction, types, causes and measures to prevent adulteration and deterioration.
- Role of ethnopharmacology in drug evaluation.
- Bio-prospecting as a tool for drug discovery.
- Concept of Reverse pharmacology.
- Holistic approach: Role of ethnobotany.

Module IV:

- Analytical profiles of herbal drugs: *Andrographis paniculata*, *Curcuma longa*, *Emblica officinalis*, *Psoralea corylifolia, Chlorophytum borivilianum, Withania somnifera.*
- Biological screening of herbal drugs: introduction and need for phyto-pharmacological screening. New strategies for evaluating natural products.
- In vitro evaluation techniques for antioxidants, antimicrobial and anticancer drugs.
- In vivo evaluation techniques for anti-inflammatory, antiulcer, anticancer, wound healing, antidiabetic, hepatoprotective, cardio protective, diuretics and antifertility studies as per OECD guidelines.

(The above-mentioned topics should be taught in the light of the recent developments in the field)

Note:- 1. Short excursion tour/visit is expected to medicinal garden/factory.

Suggested Reading

Choudhary, R. D. Herbal drug Industry, Eastern Publishers, New Delhi.

Khandelwal, K. R. (2000), Practical pharmacognosy: techniques and experiments, Nirali prakashan, Pune

Kokate, C. K., Purohit, Ghokhale. Text Book of Pharmacognosy, Nirali Prakashan

Natural products form plants (2006). Leland J. Cseke, CRC Press.

Trease, G. E. and Evans, W. C. Pharmacognosy, WB. Saunders Edinburgh, New York.

Wallis, T. E. Text Book of Pharmacognosy, J & A Churchill Ltd., London.

Elective Paper: DSE: MBO4T15: Advanced Phycology & Hydrobiology-II

Objectives

- Methods of isolation and characterization of algae.
- Methods and techniques for algae cultivation.
- Techniques involved to extract and bioactive compounds from algae for commercial purpose.

Outcomes

- The learners get skill and knowledge to undertake large scale production of natural compounds, food supplements and pharmaceuticals from algae.
- Know about commercial value of algal compounds.
- Know about the hydrobiology.

Module I:

Algal Physiology and Cultivation

- Cyanide resistance, respiration in algae, heavy metal pollution and their role in Biotechnology.
- Intracellular substance of *Spirulina, Scenedesmus, Chlorella* and marine algae.
- Algae cultures & continuous and mass cultivation in laboratory and their field applications.

Module II:

Hydrobiology (Limnology)

- Lentic environment: General consideration, physico-chemical factors, and their influence, Phytoplankton nature and adaptation of plankters, periodicity and succession, vertical distribution, productivity and factors influencing it.
- Lotic environment: General consideration, physico -chemical factors, and their influence.
- Marine benthic: General Principal, shore types, zonation patterns and factors governing them, Life forms, Geographical distribution, Marine Algae in India.

- Eutrophication and algal blooms: Definition factor: responsible for water quality, use of algal blooms and their control measures.

Module III:

- Study of phytoplankton
- Terminology, population, adaptations.
- Distribution, productivity and succession.
- Primary productivity and measurement of growth rate and natural mortality.
- Chemical features and chemical cycles in epilimnion and hypolimnion.

Module IV:

Ecology and environmental Biotechnology

- Distribution, community structure in fresh and marine water. Role of algae as indicators of pollution and its concept.
- Algae in waste water treatment, use of algal bacterial system in sewage and other waste effluents, Biomonitoring of water quality. Algae stabilization Pond.
- Eco-biotechnology for the remediation of eutrophic lentic and lotic water bodies.

(The above-mentioned topics should be taught in the light of the recent developments in the field)

Note:- 1. Short excursion tour/visit is expected to medicinal garden/factory.

Suggested Reading

A. Richmond. (2003), Hand Book of Microalgal culture. Blackwell Publishing House.

Desikachary, T.V. (1975). Marine Plants.N.C.E.R.T. New Delhi.

Desikachary, T.V.1984. Cyanophyta. ICAR, New Delhi.

Ecology - P.D. Sharma

Fogg, F. Blue Green Algae. Bishan Singh, Mahendra Pal Singh, Dehradun.

Fritsch, F.E. 1977. Structure and Reproduction of Algae. Vol. I & II. Vikash Publishing House Pvt. Ltd. New Delhi.

Fritsch, F.E. 1979. The structure and Reproduction of Algae Vol. I & II. Bishan Singh, Mahendra Pal Singh, Dehradun.

H.C. Bold and MJ. Wynne. 1978. Introduction to the Algae. Prentice Hall of India. Pvt. Ltd.

New Delhi. 10. Smith, G.M. 1957. Manual of Phycology. The Ronald Press Company. New York.

Khapekar R. R. Essentials of Limnology, Preface Book & Co., Nagpur.

Krebs, C.J. (2008) Ecology: The experimental Analysis of Distribution and Abundance (6th Edition), Benjamin Cummings Publ. 688pgs

Kumar, H.D. 1988. Introductory Phycology: Affiliated East-West Press Ltd. N. Delhi.

L. Barsanti& P. Gualtieri. (2006), Algae- Anatomy, Biochemistry and biotechnology- Taylor & Francis.

Lampert W., Sommer U. (2007)Limnoecology. The ecology of lakes and streams. The second edition. Oxford University Press.

Madigan, M.T., J.M. Martink and J. Parker (1997). Brock Biology of Microorganism. Printice hall International, Inc., New, Jersey.

Manahan, S.E. (1997) Environmental Science and Technology. Lewis, New York.

McConnaughey,B.H. (1974). Introduction to Marine Biology.

Morris, I. 1986. An introduction of Algae. Cambridge University Press U.K.

Olandao Martin. (2017). Aquatic Ecology and Biodiversity. Publisher: Callisto ISBN: 9781632398215, 1632398214.

Pandey,B.P, (1994) Algae S.Chand New Delhi.

Prescott, G.W. 1984. Algae: A review, Bishan Singh, Mahendra Pal Singh. Dehradun.

R. J Stevenson, ML Bothwell, R.L. Lowe (1996), Algal Ecology- Fresh Water Benthic Ecosystems. Academic Press, 1996.

R.K. Trivedi & Arvind Kr. Ecotechnology for pollution control & environmental management.

R.Pal and A.Choudhury ,An Introduction to Phytoplankton:Diversity and Ecology .Springer.

Ranade,D.R. and Gadre,R.V. (1988). Microbial Aspects of Anaerobic Digestion.Laboratory Manual. M.A.C.S. Pune.

Round, F.E. 1965. The Biology of the Algae, Edward Arnold. Ltd. London.

Round, F.E. 1984. Ecology of Algae. Academic. Press. London.

Sambamurthy, A.V.S.S.(2005). A Text Book of Algae.

Santhanam,R.; Ramnathan, N.;Venkataramanjan, K.andJegathanam,G.(1987). Phytoplankton of Indian Seas, and Aspects of Marine Botany. Daya Publication Home. Delhi.

Sen Neera and KumudranjanNaskar, (2003). Algal Flora of Sunderbans.

Singh, J.S., S.P & Gupta, S.R. (2006) Ecology, Environment and Resource conservation. Anamaya Publ., New Delhi, 688 pp.

Stein, J.R. (1973) : Handbook of Phycology and Biochemistry.

Stein, J.R.(1973). Handbook of Phycological Methods. Cambridge University Press.

Stewart, W.D. (1974) : Algal Physiology and Biochemistry.

Stoemer,E.F. and Smol, J.P. The Diatoms. Applications for Environment and Earth Sciences.

Tilden, J.F. 1968. The Algae and their Life Relations. Hafner Publishing Co. New York.

Trainer, F.R. 1978. Introductory Phycology. John. Wiley and Son: Inc.

Venkataraman, G.S., S.K. Goyal. B.D. Kaushik and P. Roy. Choudhary. 1974. Algae: Form and Function. Today and Tomorrow. Print. And Publication. New Delhi.

Verma& Agarwal (1995). Environmental Biology (Principles of ecology) Chand &co.,New Delhi

Vincent Jennings, (2016). Aquatic Ecology. Publishing House Syrawood, ISBN: 9781682866153, 1682866157

Wang L.K. Hung Y.T. nad Shammas N.K.(Eds).(2006) Advanced Physicochemical Treatment Processes. Springer-Verlag New York, LLC

https://uomustansiriyah.edu.iq/media/lectures/6/6_2021_10_15!03_24_13_PM.pdf.