UNIVERSITY OF CALICUT

M.Sc. PLANT SCIENCE

Course Structure, Credit and Hours distribution, and Scheme of Examination
(Effective from **2014 admission** onwards)

Semester No.	Course No.	Subjects Theory/Practical	Working Hours	Per Semester	Per Week	Credits
I	PS1C01	Phycology, Bryology and Pteridology	90	5	4	
	PS1C02	Mycology, Microbiology and Plant Pathology	90	5	4	
	PS1C03	Gymnosperms, Angiosperm Anatomy and Environmental Science	90	5	4	
	PS1P01*	Phycology, Bryology, Pteridology and Gymnosperms	90	5	4	
	PS1P02*	Mycology, Microbiology, Plant pathology and Environmental Science	90	5	4	
II	PS2C04	Cell Biology, Molecular Biology and Biostatistics	90	5	4	
	PS2C05	Genetics, Plant Breeding, Horticulture and Evolution	90	5	4	
	PS2C06	Bioinstrumentation, Biotechniques and Research methodology	90	5	4	
	PS2P03	Cell Biology, Molecular Biology, Biostatistics and Research methodology	90	5	4	
	PS2P04	Genetics, Plant Breeding, Horticulture , Bioinstrumentation and Biotechniques	90	5	4	
III	PS3C07	Plant Physiology, Biochemistry and Embryology	90	5	4	
	PS3C08	Biotechnology and Bioinformatics	90	5	4	
	PS3C09	Angiosperm Morphology, Systematics and Phytogeography	90	5	4	

	PS3P05**	Plant Physiology, Biochemistry, Biotechnology	90	5	4	
	PS3P06**	Angiosperm Morphology, Systematics, Phytogeography and Embryology	90	5	4	
IV	PS4E01	Elective Course 1	90	5	4	
	PS4E02	Elective Course 2	90	5	4	
	PS4E03	Elective Course 3	90	5	4	
	PS4Pr	Project/Dissertation	90	10	4	
	PS4V	General/Course Viva Voce	-	-	4	

* External Examinations at the end of 2nd semester; ** External Examinations at the end of 4th semester. (Internal 25%; External 75%; Duration of External Examinations: 3 hours. Total credits for the course: 80)

Practicals

Practicals courses will be conducted and internal marks awarded during the corresponding semester itself. External examinations for practical courses relating to the first and second semesters will be held at the end of the second semester and those relating to the third and fourth semesters will be held at the end of the fourth semester.

Electives

In the 4th Semester, the students can select from the following elective courses:

1. For Elective Course 1 (PS4E01) one of the following two courses:
   Agrobiotechnology ***or*** Bioethics, Biosafety and Intellectual Property Rights
2. For Elective Course 2 (PS4E02) one of the following two courses:
   Plant Tissue Culture ***or*** Horticulture.
3. For Elective Course 3 (PS4E03) one of the following two courses:
   Microbial and Plant Biomass Production and Utilisation ***or*** Phytoresources, Phytochemistry and Pharmacognosy

Project

In the fourth semester, each student has to undertake a research project and to submit a dissertation. Topic of dissertation may be chosen from any area of botany and may be laboratory-based, field-based or both or computational, with emphasis on originality or approach. It may be started during 2nd / 3rd semester and shall be completed by the end of the 4th semester.

Viva Voce

At the end of the 4th semester, each student has to attend a comprehensive viva voce which will be based on all the courses taken in the M.Sc. programme.

Record of Practical Work

A certified record of practical work done by the student should be submitted at the time of each practical examination.

Evaluation (Internal & External) and Grading

Calicut University Regulations for Credit Semester System for PG curriculum (2010) for affiliated colleges (CUCSS-PG) is to be followed for internal and external evaluation and grading.

Question Papers for External Examinations

1. For Theory Papers: There shall be 14 short-answer questions (no choice, weightage = 1)), 10 paragraph type questions (7 to be answered, weightage = 2) and 4 essay type questions (2 to be answered, weightage = 4).

2. For Practical Papers: The Board of Examiners shall decide the pattern of question paper.

SYLLABUS

Module–wise break–up of instructional hours for each course (Hours per week)

Course No.	Subjects
Semester I **Theory/practical**	
PS1C01	Phycology1½, Bryology 1½, Pteridology 2
PS1C02	Mycology 2, Microbiology 2, Plant pathology 1
PS1C03	Gymnosperms 1½, Angiosperm Anatomy 2, Environmental science 1½
PS1P01*	Phycology 1, Bryology 1, Pteridology 1½, Gymnosperms1½
PS1P02*	Mycology 1½, Microbiology 1, Plant pathology 1½, Environmental science 1
Semester II	
PS2C04	Cell Biology and Molecular Biology 3 Biostatistics 1½, Evolution ½
PS2C05	Genetics 2, Plant Breeding 1½ , Horticulture 1½
PS2C06	Bioinstrumentation 2, Biotechniques 2, Research methodology 1
PS2P03	Cell Biology and Molecular Biology 2 Biotechniques 2 , Research methodology 1
PS2P04	Genetics 2, Plant Breeding 1, Horticulture 1, Biostatistics 1
Semester III	
PS3C07	Plant Physiology 2, Biochemistry 2, Embryology 1
PS3C08	Biotechnology 3, Bioinformatics 2
PS3C09	Angiosperm Morphology 1, Systematics 3, Phytogeography 1
PS3P05**	Plant Physiology1½, Biochemistry 1½, Biotechnology 2
PS3P06**	Angiosperm Morphology½, Phytogeography ½ , Systematics 3, Embryology 1
Semester IV	
PS4E01	Agrobiotechnology
PS4E01	Bioethics, Biosafety and Intellectual Property Rights
PS4E02	Horticulture
PS4E02	Plant Tissue Culture
PS4E03	Microbial and Plant Biomass Production and Utilisation
PS4E03	Phytoresources, Phytochemistry and Pharmacognosy

Eligibility: Candidates with the following B.Sc. degrees are eligible for admission to M.Sc. Plant Science Course:

B.Sc. degree of Calicut University with Botany (main) or Plant Science (main) or an equivalent degree of any other University recognized by this University.

SEMESTER I

PS1C01 PHYCOLOGY, BRYOLOGY AND PTERIDOLOGY

Module – 1 PHYCOLOGY

1. History of Phycology: contributions of Indian Phycologists.
2. Classification of Algae: Comparison of systems of classification of F.E. Fritsch and van den Hoek *et al*. (1995) system. Modern trends in algal classification, DNA barcoding in algae.
3. Reproduction: different types of reproduction, life history patterns, parallelism in evolution, origin of higher plant groups from algae.
4. General characteristics of Cyanophyta, Chlorophyta, Xanthophyta, Bacillariophyta, Phaeophyta, Rhodophyta, Euglenophyta, Dinophyta, Chrysophyta and Cryptophyta.
5. Ecology: Ecology of freshwater forms and marine forms. Algae and pollution, Algae as indicators. Algal bloom
6. Economic importance of algae.
7. Fossil algae: A general account.
8. Algal biotechnology
   (a) Methods and techniques of collection, preservation and staining of Algae.
   (b) Algal culture: Importance, methods; Algal culture media.

Practicals

1. Collection and study of Algae mentioned below. Identification up to generic level.
2. Collection, preservation and preparation of five algal herbarium specimens.
3. Staining Techniques for permanent mounts.
4. Genera for the Practicals
   Cyanophyta: *Gloeocapsa, Oscillatoria, Microcoleus, Anabaena, Nostoc, Scytonema, Stigonema.*
   Chlorophyta: *Chlorella, Hydrodictyon, Scenedesmus, Enteromorpha, Ulva, Cladophora, Pithophora, Bulbochaete, Cephaleurous, Chaetophora, Oedogonium, Acetabularia, Bryopsis, Codium, Caulerpa, Halimeda, Desmids Closterium, Cosmarium, Mougetia, Zygnema, Chara and Nitella*.
   Xanthophyta: *Botrydium, Vaucheria*.
   Bacillariophyta: *Coscinodiscus, Pinnularia.*
   Phaeophyta: *Ectocarpus, Dictyota, Padina, Sargassum, Porphyra*.
   Rhodophyta: *Gracillaria, Gelidium.*

References:

1. Fritsch, F.E. 1945. The structure and Reproduction of Algae. Vol. 1 and 2. Cambridge University Press.
2. Smith, G.M. 1950. Manual of Phycology. Chronica Botanica Co.
3. Round, F.E. 1965. The biology of Algae. Edward Arnold.
4. Bold and Wayne. 1978. Introduction of Algae. Prentice-Hall.
5. Graham and Wilcox. 2000. Algae. Benjamin Cummings.
6. van den Hoek, C., Mann, D.G. and Jahns, N.M. 1995. Algae: An Introduction to Phycology. Cambridge University Press.
7. Barsanti, L. and Gualtieri, P. 2007. Algae: Anatomy, Biochemistry, and Biotechnology. CRC Publishers.

Module – 2 BRYOLOGY

1. General characters and systems of classification of bryophytes. barcoding in bryophytes
2. Contributions of Indian bryologists.
3. A general account of the anatomy, reproduction, life history and phylogeny of Spherocarpales, Marchantiales, Jungermaniales, Anthocerotales, Funariales, Polytricales
4. Origin and evolution of Bryophytes.
5. A general account of fossil Bryophytes and their affinities.
6. Economic importance of bryophytes.

Practicals

Morphological and structural study of representation members of following groups using cleared whole mount preparations, dissections and sections: *Riccia, Targionia, Marchantia, Porella, Anthoceros, Sphagnum, Funaria* and *Polytrichum.*

References:

1. Watson, E.V. 1971. The structure and life of Bryophytes, Hutchinson Univ. Press London.
2. Cavers, F. 1911. The interrelationship of Bryophytes. New Phytologist.
3. Kashyap, S.R. I 921. The Liverworts of Western Himalaya and the Punjab Plains, Vol. I & II. Chronica Botanica.
4. Smith, G.M. Cryptogamic Botany Vol. II. McGraw Hill. Book Co. N.Y.
5. Parihar, N.S. 1965. An introduction of Embryophyta: Bryophyta, General Book House, Allahabad.
6. Verdoon, F.M. 1932. Manual of Bryology. Ashor & Co. Amsterdam.
7. Shaw, A.J. and Goffinet, B. 2000. Bryophyte Biology. Cambridge University Press.

Module – 3 PTERIDOLOGY

1. General characters, Classification (modern trends) and life cycle of Pteridophytes, Contribution of Indian Pteridologists.
2. Diversity of forms among Pteridophytes club mosses, quill worts., mosquito ferns, braken ferns, bird's nest fern, maiden hair fern and tree ferns general morphology with special reference to South Indian species.
3. Fossil Pteridophytes, Psilophytales, Lepidodendrales Calamitales, and Primoficales morphological and anatomical features.
4. Habitat ecology of Pteridophytes, epiphytes, lithophytes, climbers, halophytes, sciophytes, xerophytes, rheophytes, hydrophytes.
5. Structure and evolution of stele in Pteridophytes.
6. Origin and evolution of sporangium – heterospory and seed habit.
7. Development and evolutionary trends in the gametophytes of pteridophytes
8. Cytology of Pteridophytes, Chromosome number, polyploidy, origin of polyploids, apospory, apogamy, agamospory, vegetative reproduction and hybridization.
9. Applied Pteridology, Biofertilizer production from *Azolla*, *Azolla Anabaena* symbiosis – Biochemistry of nitrogen fixation – nif genes. Pteridophytes as weeds – *Salvinia* (Aquatic) *Pteridium* (Terrestrial) Weed problem, weed control – impact and management – Biological control. Ornamental and medicinal Pteridophytes. Pteridophytes as ecological indicators.

Practicals

1. Morphological anatomical and reproductive features of *Ophioglossum, Angiopteris, Osmunda, Lygodium, Ceratopteris, Pteris, Blechnum, Asplenium, Trichomanes, Acrostichum, Salvinia and Azolla*.
2. Fossils – *Rhynia, Lepidodendron, Calamites, Botryopteris*.
3. Spore germination and development of prothallus in Knop's agar medium.
4. Habitat study of *Lycopodium, Gleichenia, Actiniopteris, Pyrrosia, Drynaria, Acrostichum, Salvinia*.
5. Submission of 5 herbarium specimens of local pteridophytes.

References:

1. Bierhost, D.W. 1971. Morphology of Vascular Plants, Mac. Millan Co., New York.
2. Dyer, A.C. 1979. The experimental Biology of Ferns. Academic Press, London.
3. Jermy, A.C. 1973 (Ed.). The Phylogeny and Classification of Ferns.
4. Kramer, K.U. & Green, P.S. 1991. The Families and Genera of Vascular Plants, Narosa, New Delhi.
5. Sporne, K. R 1966. The Morphology of Pteridophytes: The Structure of Ferns and Allied Plants. Hutchinson.
6. Chandra, S. and Srivastava, M. 2003. Pteridology in the New Millennium. Kluwer Academic Publishers.

PS1CO2 MYCOLOGY, MICROBIOLOGY AND PLANT PATHOLOGY

Module – 1 MYCOLOGY

1. General characteristics of fungi: thallus organization, modes of nutrition, cell wall and hyphal tip growth, fungal organelles, reproduction and spores, vegetative incompatibility and sexual compatibility, parasexuality.
2. Kingdoms of fungi: Fungi, Chromista, Protozoa; phylum-level classification Alexopoulos *et al.* 1996, and Kirk *et al.* (2008); Characters used in fungal classification, DNA Barcoding in fungi
3. Biology, general characteristics and classification of the following phyla: Myxomycota, Oomycota, Chytridiomycota, Zygomycota, Glomeromycota, Ascomycota and Basidiomycota.
4. Asexual fungi (Deuteromycetes): General characters, habit and importance of asexual fungi, somatic structures, and structures associated with asexual reproduction, conidomata, conida and conidium ontogeny, other asexual propagules, teliomorph-anamorph connections, nomenclature and classification.
5. Fungi as symbionts: mycorrhizae, endophytes, insect–symbionts
6. Role of fungi in decomposition of cellulose and lignin
7. Lichens: thallus structure, nutrition, reproduction, mutualistic interaction, ecological and economic significance.
8. Economic importance of fungi.

Practicals

1. Using appropriate mycological methods and techniques the students shall collect and study the morphology and anatomy of the reproductive structures of the following genera of fungi *Stemonites, Synchytrim, Saprolegnia, Pythium, Albugo, Pilobolus, Mucor, Saccharomyces, Taphrina, Erysiphe Ascobolus, Xylaria, Geoglossum, Phomopsis, Drechslera, Aspergillus, Alternaria, Cercospora, Fusarium, Pleurotus,*

Tremella, Auricularia, Puccinia, Ustilago, Ganoderma, Lycoperdon, Geastrum, Dictyophora, Cyathus, Parmelia and Usnea.

2. Collection, identification and submission of 5 locally available genera.

References:

1. Alexopoulos, C.J. *et al*. 1996. Introductory Mycology, 4th Edition, Wiley.
2. Carlile, M.J. and Watkinson, S.C. 2001. The Fungi. Academic Press.
3. Deacon, J.W. 2005. Introduction to Modern Mycology, Blackwell.
4. Jennings, D.H. and Lysek, G. 1999. Fungal Biology. Bios Scientific Publishers.
5. Kavanagh, K. (ed.) 2005. Fungi – Biology and Applications. Wiley.
6. Moore–Landecker. 1996. Fundamentals of Fungi. Cambridge University Press.
7. Nash, T.H. 1996. Lichen Biology. Cambridge University Press.
8. Webster, J. and Weber, R. 2007. Introduction to Fungi. Cambridge University Press.

Module - 2 MICROBIOLOGY

1. Bacteria: (a) Classification of Bacteria according to Bergey's manual of systematic bacteriology. Major groups of Bacteria: Spirochetes, Rickettsias, Chlamydias, Mycoplasmas, Actinomycetes. DNA Barcoding in bacteria, Myxobacteria, Archaebacteria: - extremophiles, thermophilic, halophilic, acidophilic, alkalophilic bacteria and methanogenic bacteria
   (b) Ultra structure of Gram positive and Gram negative bacteria; cell membrane, cell wall, flagella, pili, fimbriae, capsule and slime, ribosome and endospores.
   (c) Nutrition, cultivation, growth, genetics, plasmids and their characteristics.
2. Viruses: General account of plant and animal viruses and bacteriophages; classification of viruses; detailed study of plant viruses including their morphology, structure, isolation, purification, assay, infection, replication and transmission; viroids and prions.
3. Methods in microbiology: culture media and their preparation, methods of sterilization, isolation of pure cultures, cultivation of anaerobic bacteria, maintenance of microbial cultures, estimation of microbial number and biomass, bacterial staining.
4. Agricultural microbiology: Management of agricultural soils, biofertilizers and biopesticides.
5. Microbial Technology: industrial microorganisms and products, primary and secondary metabolites, production of alcohol, vinegar, antibiotics, vitamins, steroids, vaccines, organic acids, enzymes, fermentation technology - fermentor design and operation, upstream and downstream processes,

Practicals

1. Isolation of bacteria from soil by dilution plate method.
2. Isolation of pure bacterial culture by streak plate method.
3. Staining of bacteria and their spores.
4. Demonstration of bacterial motility by hanging drop method.

References:

1. Madigan, M. T. *et al*. 2008. Brock Biology of Microorganisms. Benjamin Cummings
2. R.Y. Stanier *et al*. 1990. The Microbial World. Prentice Hall.
3. R.E.F. Mathew. 1991. Plant Virology, 3rd ed. Academic Press.
4. M. Goodfellow *et al*. 1983. The Biology of Actinomycetes. Academic Press.
5. Pelczar, M.G, Chan E.C.S. and Krieg N.R. 1986. Microbiology, Tata McGraw Hill.
6. Prescott, L. M. *et al*. 2005. Microbiology. McGraw Hill
7. Singleton, P. 2004. Bacteria in Biology, Biotechnology and Medicine. Wiley.

Module – 3 PLANT PATHOLOGY

1. Concepts of plant diseases causes and classification.
2. Symptoms of plant diseases.
3. Disease development: infection, progress of disease, role of enzymes and toxins
4. Defense mechanisms: structural and chemical
5. Effect of environment on plant disease development.
6. Plant disease management: control measures that exclude or eradicate pathogen, direct protection of plants from pathogens by biological control and chemical control, types of chemicals used for plant disease control, regulatory methods, control through use of transgenic plants, integrated control of plant diseases.
7. Major Diseases
   (a) Cereals: Rice – blast disease, bacterial blight; Wheat – black rust disease.
   (b) Vegetables: Chilly – leaf spot; Okra – leaf spot.
   (c) Fruits: Banana – bunchy top; Mango – Anthracnose; Citrus – bacterial canker; Papaya – mosaic.
   (d) Spices: Ginger – rhizome rot; Pepper – quick wilt;
   (e) Oil seeds: Coconut – grey leaf spot, bud rot disease.
   (f) Rubber yielding crops: *Hevea braziliensis* – abnormal leaf fall, powdery mildew.
   (g) Sugar yielding crops: Sugarcane – red rot
   (h) Cash crops: Arecanut – nut fall disease.
   (i) Beverage crops : Tea – blister blight; Coffee – rust
   (j) Tuber crops :Tapioca-mosaic virus

Practicals

1. Study of the following diseases with reference to signs and symptoms in the laboratory and collection of 5 locally available plant disease specimens.
2. Blast disease of Rice, – black rust disease of Wheat, Chilly – leaf spot; okra – leaf spot disease, Banana – bunchy top; Mango – Anthracnose; Citrus - bacterial canker; Ginger – rhizome rot; Pepper – quick wilt; Tikka disease of ground nut, Coconut – grey leaf spot, bud rot disease. *Hevea braziliensis* – abnormal leaf fall, powdery mildew. Sugarcane – red rot, Arecanut - nut fall disease, cassava mosaic, Coffee – rust.

References:

1. Agrios G.N. 2005. Plant pathology, 5th ed. Academic Press.
2. Lucas, J.A. 1998. Plant Pathology and Plant Pathogens, 3rd ed. Blackwell.
3. Mehrothra R.S. 1980. Plant Pathology. Tata-McGraw Hill
4. Smith K.M. 1973. A text book of plant virus diseases, 3rd ed. Academic Press.
5. Rangaswami G. 1988. Diseases of crop plant of India, 3rd ed. Prentice Hall, India
6. Scheffer, R.P. 2007. The Nature of Disease in Plants. Cambridge University Press.
7. WaIler, J.M., Lenne J.M. and WaIler S.J. (Ed.) 2001. Plant Pathologists' Pocketbook.

PS1CO3 GYMNOSPERMS, ANGIOSPERM ANATOMY AND ENVIRONMENTAL SCIENCE

Module – 1 GYMNOSPERMS

1. General characters: Phylogeny, Classification. DNA barcoding in gymnosperms,
2. Geological horizons, distribution, general account including morphology, anatomy, phylogeny and interrelationship of the following orders with special emphasis on the genera specified.

a) Pteridospermales: *Lyginopteris, Heterangium, Sphenopteris, Sphaerostoma, Lagenostoma, Medullosa*,
b) Glossopteridales: *Glossopteris*
c) Caytoniales*: Caytonia*
d) Cycadoideales: *Williamsonia*
e) Pentoxylales: *Pentoxylon*
f) Cycadales: *Zamia*
g) Ginkgoales*: Ginkgo*
h) Coniferales: *Cedrus, Cryptomeria, Cupressus, Agathis, Podocarpus.*
i) Taxales: *Taxus*
j) Ephedrales: *Ephedra*
k) Welwitschiales: *Welwitschia*
l) Gnetales: *Gnetum*

3. Distribution of living and fossil gymnosperms in India.
4. Economic importance of gymnosperms.

Practicals

1. Identification of petrifications, compressions, impressions, slides of fossil types include in groups mentioned above.
2. Comparative study of vegetative and reproductive structures of the living genera mentioned above.
3. Morphological and anatomical studies of above mentioned taxa.

References:

1. Andrews, H.N. 1961. Studies in Paleobotany, Wiley.
2. Banks, H.P. 1970 Evolution and plants of the past. Wadsworth.
3. Bierhost, D.W. 1971. Morphology of vascular plants, Macmillan.
4. Bower F.O. 1935. Primitive plants. Macmillan.
5. Chamberlain, C.J. 1935. Gymnosperms structure and evolution. Univ. of Chicago Press.
6. Foster, A.S. & E.M. Gifford. 1974. Comparative morphology of vascular plants. Freeman.
7. Maheshwari, P & V. Vasil. *Gnetum*. CSIR, New Delhi.
8. Ramanujam, C.G.K. 1976. Indian Gymnosperms in time and Space. Today & Tomorrow's Printers & Publishers, New Delhi.
9. Sewart, W.N. 1983. Paleobotany and the evolution of plants. Cambridge Univ. Press.
10. Stockey, R.S. 1981. Some comments on the origin and evolution of conifers. Canadian J. Bot. 59: 75-82.
11. Taylor, T.N. 1982.Reproductive biology in early seed plants. Bioscience 32: 23-28.
12. Walton, J.1953. An introduction to the study of fossil plants. A & C Black, London.

Module – 2 ANGIOSPERM ANATOMY

1. Scope and significance of plant anatomy, interdisciplinary relations. Differentiation: Concept, its significance in developmental studies.
2. Meristems: Recent theories on organization of root and shoot apical meristems. Origin of lateral root. Leaf and bud development. Plastochronic stage, experimental studies on meristems, vegetative to reproductive apex. Reversion from reproductive to vegetative apex.
3. Tissue systems: Differentiation and functions of different tissue systems such as epidermis, parenchyma, chlorenchyma, sclerenchyma, laticifers, glands, transfer cells.

Environmental factors influencing differentiation of the divergent tissue systems, experimental studies, and their economic importance.

4. Secondary cambium: Concept, classification, origin and constitution of cambium, cambial activity, cambium in wound healing and grafting, factors influencing cambial differentiation and activity, cork-cambium, different types, origin and function.
5. Abnormal Cambium: Classification, origin and function, experimental studies.
6. Seedling and nodal anatomy, root cot vascular connection, pattern of nodal anatomy, controversies on phylogenetic trends in nodal anatomy.
7. Xylem: Origin, Structural features and function of fibres, fibre trachieds, trachieds, vessel elements, xylem parenchyma, the trends of specialization, taxonomic significance, factors affecting xylem differentiation, elements of wood anatomy.
8. Phloem: Origin, structure and function of sieve cells, sieve tubes companion cells and fibres, trends of specialization, taxonomic significance, factors affecting phloem differentiation.
9. Leaf: Origin and development of lamina – general pattern.
10. Fruit and seeds: general anatomy of fleshy and dry fruits-anatomy of seeds in general, development dormancy and drought resistance from anatomical point of view.
11. Roots: Initiation and development of specialized roots.
12. Applied anatomy: Applications of anatomy in systematics (histotaxonomy) and Pharmacognosy. Research prospects in anatomy

Practicals

1. Diversity in cells and tissue in a monocot and dicot plant with respect to position, distribution, structure and function.
2. Epidermis – Trichomes, stomatal types, stomatal index.
3. Clearing shoots apical meristems – different patterns.
4. Clearing and staining of leaf, young twigs, roots, floral parts etc.
5. Nodal anatomy.
6. Vascular cambium and cork cambium.
7. Xylem and its constituents by sectioning and macerating the tissues.
8. Phloem and its components.
9. Abnormal secondary growth – different patterns: *Dracaena, Bignonia, Aristolochia, Amaranthus, Nyctanthes, Aerva,* Beetroot, *Mirabilis, Pisonia, and Bougainvillea*

References:

1. Esau, K. 1983. Plant anatomy. Wiley Eastern Limited.
2. Fahn, A. 1977. Plant anatomy. Pergamon Press.
3. Cutter, E.G. & Edward, E. 1978. Plant Anatomy: Experiment and Interpretations Part 1 & 2. Edward Arnold.
4. Mauseth, J.D. 1988. Plant anatomy. The Benjamin Cumming Publishing Co.
5. Forester, A.S. 1960 Practical Plant anatomy. D. Van Nostrand Company Inc.
6. Roberts, L.W. 1976. Cytodifferentiation in plants. Cambridge University Press.

Module – 3 ENVIRONMENTAL SCIENCE

1. Ecosystem – Structural components, relationship between structural and function; trophic structures Significance of habitat, ecological niche
2. Productivity and energy flow – concept, limits and processes of primary production; efficiency with regard to energy capture and transfer.
3. Succession, climax and stability – concepts, characteristics of pioneer and climax species; climax concept and stability.

4. Population characteristics – density, diversity indices, alpha beta and gamma diversity, natality, mortality, age distribution, biotic potential, carrying capacity, aggregation, dispersal, ecotone and edge effect. Growth curve, population regulation, life history strategies.
5. Classification of communities – criteria of classification, dynamic system of classification by Clement.
   (b) Special plant communities - quantitative, qualitative and synthetic characteristics of plant Communities, Sorenson's Index of similarity, coefficient of communities.
6. Genecology – basic concepts, ecotype, ecophenes, ecads. , k-selection and r-selection
7. Environmental pollution – types Land pollution: Concept of waste, types and sources of solid wastes including e-waste. pesticides, Bioremediation, Phytoremediation, bioaugmentation, biofilms, biofilters, bioscrubbers and trickling filters.
   Water: Types of water pollution different types of pollutants and their consequences, prevention and control: Minamata and Love Canal episodes, Water quality parameters and standards.
   Air pollution: types and sources of air pollutants, air pollution and human health hazards, control of air pollution.
   Radiation, noise and automobile pollution; effect on plant; control with emphasis on biological methods,
   Global environmental change; El Nino, La Nina, green house effect, Ozone depletion, Ozone day biodiversity status, climate change
8. Environmental monitoring and bio indicators, environmental safety provisions in Indian constitution, major environmental laws in free India, ISO-14000.
   Biodiversity loss - concept of endemism, rare, endangered and threatened species (RET), key
   stone species, IUCN account of biodiversity, red data book and hot spots, reasons to stop extinction, methods to save species.
   Principles of conservation - *ex-situ* and *in-situ* conservation techniques.
   Biodiversity conservation: Species diversity, community diversity, ecosystem diversity and landscape preservation. Role of biotechnology in conservation of species.
9. Ecotourism – General account

Practicals

1. Analysis of water quality for; (a) Dissolved CO_2 (b) Dissolved oxygen (c) Quantitative estimation of dissolved chloride ions (d) dissolved sulphate (f) Total alkalinity.
2. Physico-chemical analysis of soil: (a) Total water soluble mineral ions (b) estimation of soil organic carbon (Walkey and Black method).
3. Quantitative and qualitative community analysis. Carry out a project on species structure and the frequency, abundance, density of different species, IVI and similarity index of different communities in a natural system. Students must be able to explain the structure of vegetation from the given data on the above mentioned characteristics.
4. Phytoplankton counting using Sedgwick Rafter counter.
5. Field visit to natural ecosystem and identification of trophic levels, food webs and food chains, plant diversity (species and community).
6. Students should be aware of the common environmental problems, their consequences and possible solutions.
7. Visit to a wild life sanctuary/ national park

References:

1. Agarwal, V.P., 1988. Forests in India. Oxford & IBH Publishing Co. Pvt. Ltd.
2. Clarks, G.L. 1954. Elements of Ecology. John Wiley & Sons.

3. Cox, G.W. 1969. Readings in Conservation Ecology. Appleton-Century-Crofts.
4. Dasman, R.F. 1968. Environmental conservation. John Wiley and Sons.
5. Lucas, U. & Synge, H., 1986. IUCN Plant Red Data book. IUCN
6. Misra, R. 1968. Ecology Workbook. Oxford-IBH Publishing Co.
7. Nayar, M.P, & Sastry, A.R.K. 1987, 1989, 1990, Red Data Book of Indian Plants. 3 VoIs. Botanical Survey of India.
8. Odum, E.P. 1976. Fundamentals of Ecology. W. B. Sanders.
9. Odum, E.P. 1983. Basic Ecology. W.B. Saunders
10. Puri, G. Indian Forest Ecology.1983. Oxford-IBH Publishing Co.

SEMESTER II

PS2CO4 CELL BIOLOGY, MOLECULAR BIOLOGY AND BIOSTATISTICS

Module – 1 CELL BIOLOGY & MOLECULAR BIOLOGY

1. Cells & their environment: functions of cellular junctions, cell wall, cell membrane; membrane potential
2. Ultra structure, composition & functions of mitochondria, plastids; Structure of ATP Synthase, Chaperones & Chaperonins, Kinetoplast; Mitochondrial Heterosis, Mitochondrial Abnormalities of Plants & Mitochondrial Diseases. Chloroplast Import, Photosynthetic Domains, Chlorophyll Binding Proteins; Chlorosomes & Chromatophores, Cell Vacuoles, Endocytosis & Exocytosis.
3. Microbodies: Glyoxisomes, Peroxisomes, Oxalosomes, Glycosomes, Hydrogenosomes; Ribosomes: Different Types (Prokaryotic, Eukaryotic, Cytoplasmic, Organellar, etc.), Polysomes.
4. Nucleus: Ultra Structure, Nuclear Membrane, Nuclear Pore Complex, Euchromatin, Heterochromatin, Prochromatin, Antichromatin, Nucleolus, Nuclear Matrix, Nuclear Lamina & Chromatin Assembly Factor (CAF).
5. Chromosomes: Structure, Chemistry and Organization, Kinetochore, Satellites, Chromomeres, Chromosome Knobs, Special types of Chromosomes: Polytene Chromosomes & Lamp Brush Chromosomes, Structure & Significance of Giant Chromosomes in Plants, B-Chromosomes, Micro & Mega Chromosomes
6. Cytoskeleton & Cell Cycle – Molecular Motors, Microfilaments & Microtubules, Actins & Tubulins, Microtubule Associated proteins (MAP) - Dynein, Dynactin, Kinesin, Kinectin. Mitosis & Meiosis – Chromosome Mechanisms and Events, Regulation of cell cycle
7. Programmed cell death- regulatory proteins, pathways, cell signaling; Cancer- Tumor suppressor genes, Genetic basis of malignant transformation, oncogenes, cancer and cell cycle.
8. Molecular Structure of DNA: Topology of DNA, Forms & types of DNA (Super Helical- Circular, Nicked-Circular, Linear, Satellite, selfish,), Types of DNA - A, B, C, D, E, H, Z, RL Helix & Triple Helix; Organellar DNA (ct DNA & mt DNA); Replication of DNA: DNA Replication In Vivo, Types of DNA Replication (Conservative, semiconservative & dispersive), Enzymology of replication
9. Gene Expression & Gene Regulation: Transcription in Prokaryotes, Transcription & RNA Processing in Eukaryotes, RNA Splicing & Spliceosomes, Introns, Intron Homing, Exons, Exon Shuffling, RNA Editing; Structure & Composition of RNA - rRNA, mRNA, tRNA (Clover Leaf Model & 'L'- Shaped Tertiary Conformation) & snRNA; Genetic Code; Protein Synthesis & Protein Synthesis Inhibitors; Genetic

regulation in Prokaryotes, Operon Concept (lac Operon, trp Operon,.), Gene Expression in Eukaryotes

10. Mutation & DNA Repair Mechanisms: Somatic & Germinal Mutations, Spontaneous & Induced Mutations, Environmental Mutagens, Molecular Basis of Mutation, DNA Repair Mechanisms (Light-Dependant-, Excision-, Mismatch-, Post Replication- & SOS Repair).

Practicals

1. Study of mitotic index of the specimen supplied.
2. Camera Lucida drawings of Karyotype from a permanent slide.
3. Study of meiosis in *Datura/Rhoeo/Chlorophytum* by smear preparation of PMCs.
4. Study of giant chromosomes in Drosophila.
5. Exercises related to the theory parts have to be worked out.
6. Extraction of DNA/RNA from plant tissues.
7. Isolation and staining of DNA/RNA from plant tissues.
8. Colorimetric estimation of DNA by Diphenylamine method.
9. Colorimetric estimation of RNA by Orcinol method.
10. Extraction and isolation of nucleic acid from leaf tissue.

References:

1. Pon, L.A. & Schon, E.A. 2001. Mitochondria. Academic Press.
2. Scicchitano, D. 1998. Molecular Cell Biology W. H. Freeman & Co.
3. Karp, G. 2004. Cell and Molecular Biology: Concepts and experiments. 4th Edition. Wiley.
4. Alberts, B. *et al*. 2007. Molecular Biology of the Cell. Taylor & Francis Inc.
5. Morris, K.V. 2008. RNA and the regulation of gene expression: A hidden layer of complexity. Caister Academic Press.
6. De Robertis, E.D.P. & De Robertis, E.M.F. 1987. Cell and Molecular Biology. Lea & Febiger.
7. Turner, B.M. 2002. Chromatin and Gene Regulation. Blackwell Publishing Co.
8. Allison, L. 2007. Fundamental Molecular Biology. Blackwell Publishing Co.
9. Carroll, S. 2004. From DNA to Diversity. Blackwell Publishing Co.
10. Glick, B.R. & Thompson, J.E. 1993. Methods in Plant Molecular Biology and Biotechnology, Promega.

Module – 2 BIOSTATISTICS

1. Quantitative methods in biology- introduction
2. Methods of data collection- primary and secondary data- census and sampling methods.
3. Tabulation and presentation of numerical data- diagrammatic and graphical presentation.
4. Measures of central tendencies- mean, median and mode. Skewness and kurtosis.
5. Measures of variations- range, quartile deviation, mean deviation- variance and standard deviation. Standard error and Coefficient of variation.
6. Tests of significance- z, t and χ^2tests.
7. Analysis of variance.
8. Correlation and regression analysis.
9. Factor and cluster analysis.
10. Experimental designs.

Practicals

1. Diagramatic and graphic representation of data using programmes like MS Excel, Open office Calc or Statistica.
2. Analysis of numerical data for mean, median, mode, variance, standard deviation, standard error and coefficient of variation.
3. Analysis of variance between data from different samples using MS Excel.
4. Calculation of correlation coefficient between groups of data and calculation of critical difference.

References:

1. Pagano M. and Gauvreau K.2000. Principles of Biostatistics. Duxbury.
2. Sharma J.R.2008. Statistical and biometrical techniques in Plant Breeding. New Age International Publishers.
3. Panse V.G. and Sukhatme, P.V. Statistical Methods for Agricultural Workers. ICAR.
4. Rangaswamy R. A .2009.Text Book of Agricultural Statistics. New Age International Publishers.
5. Jasra P.K. Biostatistics. Krishna Prakashan Media (P) Ltd.

PS2CO5 GENETICS, PLANT BREEDING, HORTICULTTURE AND EVOLUTION

Module – 1 GENETICS

1. Mendelism- Mendelian factors-discussion on Mendel's paper, factor segregation of mendelian factors- dominance, codominance and incomplete dominance of mendelian factors. penetrance and expressivity of genes.
2. Independent assortment- interaction of genes- multiple allelism
3. Chromosomal theory of inheritance
4. Plasmagenes- cytoplasmic inheritance- chloroplast gene *Mirabilis jalapa* and *Zea mays* and mitochondrial genes- petite , cytoplasmic male sterility in plants, maternal effect in inheritance in *Limnaea peregra*
5. Quantitative genetics-inheritance of quantitative traits, corolla length in *Nicotiana*, cob length in *Zea mays*, Multiple factors- continuous variation- continuous and threshold traits- QTL- Heritability- transgressive variation.
6. Linkage and Crossing over - Stern's hypothesis, Creighton and McClintock's experiments, single cross over, multiple cross over, two-point cross, three-point cross, map distances, gene order, interference and co-efficient of coincidence. Haploid mapping (*Neurospora*), Mapping in bacteria and bacteriophages.
   Inheritance of traits in humans; pedigree analysis, determination of human genetic diseases by pedigree analysis, genetic mapping in human pedigrees.

6. Genetics of sex determination- sex linkage- sex linked, sex influenced and sex limited characters- sex linked lethal mutations.

7. Genetic basis of cancer. Proto-oncogenes, oncogenes, conversion of proto-oncogenes to oncogenes.
   Tumor suppressor genes – functions, role of p53. Viral oncogenes.

8. Biometrical genetics- probability and genetics- prediction of genetic behaviour- statistical tools in genetic analysis.
9. Behavioural genetics- Genetics of biorhythms- genetics of mammalian clock- genetics of behaviour.
10. Applied genetics- Eugenics, euphenics and euthenics Immunogenetics.

11. Genetic structure of populations and its change - Hardy–Weinberg equilibrium – Sewall Wright effect
    Factors that alter allelic frequencies; (i) mutation (ii) genetic drift - bottle neck effect and founder effect (iii) migration (iv) selection (v) nonrandom mating, inbreeding coefficient.

Practicals

1. Problems based on independent assortment, gene interaction and multiple allelism.
2. Problems based on linkage and chromosome mapping.
3. Problems based on quantitative genetics
4. Problems based on population genetics

References:

1. Kowles R. Solving Problems in Genetics. Springer.
2. Sambamurthy A.V.S.S. Genetics. Narosa Publishing House.
3. Brooker R. J. Genetics: Analysis and Principles Addison Wesley Longman Inc.
4. Hedrick P. W. Genetics of Populations. Jones and Bartlett Publishers.
5. Griffiths A.J.F., Gelbbart W. M., Lewontin R.C., Miller J.H. Modern Genetic Analysis. WH Freeman & Company.
6. Dabholkar A.R. Elements of Biometrical Genetics. Concept Publishing Company.
7. Frankel O.H. and Bennet E. Genetic Resources in Plants. Blackwell.
8. Hotter P. Text book of Genetics. Ivy Publishing House.
9. Satpathy G.C. Genetics. Kalpaz Publications.

Module – 2 PLANT BREEDING

1. Introduction – Objectives in Plant breeding, Floral Biology in relation to selfing and crossing techniques.
2. Biological foundations of Plant breeding- Role of heredity and environment in character expression- Systems of reproduction in plants- Mating systems in sexually reproduced plants.
3. Plant propagation- sexual, pseudosexual and asexual methods- special methods of plant propagation- micropropagation.
4. Conventional methods of plant breeding- plant domestication, plant introduction, selection and hybridization.
5. Breeding Methods: Sources of plant germplasm. Centres of genetic diversity. Concepts of de-Candolle and Vavilov Primary, secondary and microcenters. Genetic erosion – causes threatened species. Plant genetic conservation – (in-situ and ex-situ).
6. Plant introduction: Types and procedures. Preservation and utilization of germplasm.
7. Selection: Principles – genetic basis and methods. Mass selection, pure line selection, clonal selection.
8. Hybridization : Objectives, choice of parents, problems and causes of failure of hybridization – Incompatibility and sterility – Methods of overcoming – genetic consequences of hybridization. Methods of handling segregating hybrids for isolation of superior strains – Bulk method and pedigree method of selection. Role of interspecific and intergeneric hybridization in plant improvement.
9. Back-cross breeding: Theory and procedure for transferring various types of characters. Inbreeding consequences. Heterosis theories – genetic and physiologic basis – Applications in plant breeding – steps in the production of single cross, double cross, three way cross and synthetic cross – use of male sterility in hybrid production – cytoplasmic – Genetic and cytoplasmic – Genetic sterility.

10. Polyploidy breeding induction of autopolyploidy and allopolyploidy, role of chromosome manipulation – chromosome addition and substitution lines achievements.
11. Mutation breeding: Situations suitable for mutation breeding. Materials needed for treatment. Physical and chemical mutagens. Handling of mutants. Evaluation of mutants in M1, M2 and M3 generations.
12. Breeding for special purposes- breeding for pest, disease and stress resistance.

References:

1. Allard R. W. - Principles of Plant Breeding. John Wiley & Sons.
2. Jain H. K. and Kharkwal M. C. Plant Breeding. Narosa Publishing House.
3. Chahal G. S. and Gosal S. S. Principles and Procedures of Plant Breeding. Narosa Publishing House.
4. Roy D. Plant Breeding. Narosa Publishing House.
5. Hayward M. D., Bosemark N. O. and Romagosa I. Plant Breeding- Principles and prospects. Chapman and Hall.
6. Gupta S.K. Plant Breeding. Agrobios.
7. Khan M. A. Plant Breeding. Biotech Books.
8. Sharma J. R. Plant Breeding. Tata McGraw Hill.

Module – 3 HORTICULTURE

1. Concept and scope of horticulture.
2. Basic requirements — land, water, soil, landscape, propagules, implements and practices — types of garden plants.
3. Plant growing structures – Green house, Glass house and Mist chamber.
4. Plant propagation – Cuttage, Layerage, Graftage and Budding.
5. Cultural practices – Thinning, Training, Trimming and Pruning.
6. Fertilizers – Biofertilizer, Green manure, NPK, Compost – Vermicompost
7. Out door horticulture – Gardens – Vegetable garden, Medicinal plant garden Roof garden, Fruit garden, Lawns and Landscapes.
8. Commercial horticulture – Nurseries, Indoor plants and flowers.
9. Arboriculture – Pruning, bracing, feeding and transplanting. Bonsai.
10. Floriculture – commercial floriculture – Production of cut flowers and home floriculture.
11. Disease and pest control in gardening- Fungicides and pesticides.
12. Plant growing problems and their control.

Practicals

1. Budding – ‘T’ Budding and Patch Budding
2. Layering – Any two methods.
3. Grafting – Any two methods.
4. Tools and implements.
5. Determination of soil pH

References:

1. Hartmann H.T, Kester D.E., Davies F.T and Geneve R.L. 1997. Propagation and practicll6th Edn. Prentice Hall of lndia, Pvt. Ltd. New Delhi.
2. Lancaster P 1997. Gardening in India. Revised by Bose T.K. and Mukherjee D.
3. Laurie A and Ries V. 1956. Floriculture: fundamentals and practices Mc Graw Hill Book Co. Inc. N.Y. Trinidad, London.

4. Macmillan 1962. Tropical planting and gardening, 5th Edn. Macmillan Co. Ltd. London.
5. Northen TH. and Northen RT 1956. The complete book of green house gardening. The Ronald Press Co. New York.
6. Pearce S .A. 1961. Ornamental tree: For gardening and roadside planting: W. H & L Collingridge Ltd. London.
7. Prakash R Choudhary D. C. and Nagi S.S. 1991. Propagation practice of important Indian trees. IntI. Book Distributors, Dehra Dun.
8. Radford A.E. 1986. Fundamentals of plant systematics. Harper & Row Publ. Inc.
9. Hay R.(Ed.) 1960. The modern garden. G. Arthur Pearson Ltd. London.
10. Shoemaker J.S. and Teskey BJ.E. 1965. Practical Horticulture. John Wiley & Sons. Inc. London

Module – 4 EVOLUTION

1. Origin and evolution of life
2. Classical and synthetic theories of evolution
3. Forces of evolution, Mechanism of evolution
4. Species concept, Speciation
5. Isolation mechanisms
6. Evolution above species level
7. Molecular evolution

References:

1. Barton, N. H. *et al*. 2007. Evolution. Cold Spring Harbor Laboratory Press.
2. Kardong, K. V. 2007. An introduction to biological evolution. McGraw-Hill.
3. Ridley, M. 2004. Evolution. Oxford University Press.

PS2C06 BIOINSTRUMENTATION, BIOTECHNIQUES AND RESEARCH METHODOLOGY

Module - 1 BIOINSTRUMENTATION AND BIOTECHNIQUES

1. Microscopy: - Principle and application of Simple, Compound, Phase contrast, Fluorescence, Electron (SEM and TEM) microscopy, Micrometry, Scanning tunneling microscopy, Atomic force microscopy, Confocal microscopy, Cytophotometry and Flow cytometry. Photomicrography, Camera Lucida.
2. Electrochemistry:- pH and buffers.
3. Centrifugation: - Rotors, Bench top, Low speed, High speed, Cooling, Ultracentrifuge.
4. Spectroscopy: - Principle and applications of UV, Visible, IR, Raman, Spectroflurometry, Mass, AAS, NMR, ESR, MS and MALDI-TOF.
5. Electrophoresis: Principle and applications of Native, Isoelectric focusing and SDS PAGE; Agarose and 2D gel electrophoresis.
6. Detecting DNA Polymorphism: Principle, methods and applications of RFLP, AFLP, RAPD.
7. Principle of biophysical method and used for analysis of biopolymer structure:-X ray diffraction, flurorescence.
8. Use of Radioisotopes: GM counting, Scintillation counting, Autoradiography.
9. Immunological techniques:-Antigen-Antibody interaction. immunofluorescence, Immunodiffusion, Immunoprecipitation, Immunoelectrophoresis, RIA, ELISA.
10. Chromatography: Paper, TLC, Column, Gel Filtration, Affinity, Ion Exchange, HPLC, GC.

11. Fixation and storage**:-** Classification of fixatives, formulas. (Plant and microbial samples) Factors affecting fixation. Procedures for fixation. Dehydration, infiltration and embedding. Media for embedding.
12. Microtomy**:** Rotary, sliding cryostat, ultra microtome and freezing ultra-microtome.
13. Preparation of biological samples for light and electron microscopy**:-** Sectioning, maceration, squash and clearing technique. Freeze etching and freeze fracturing.
14. Stains for light microscopy**:** Staining procedures.
15. Nucleic Acid Hybridization**:** Principle of Hybridization, Blotting Techniques (Southern blotting, Northern blotting, South-Western blotting, Western blotting)
16. Polymerase Chain reaction**:** Principle, Procedure, Variations and Applications.
17. Nucleic Acid Sequencing**:** Maxam Gilbert method, Sanger method
18. Construction of DNA Library**:** Genomic DNA Library - isolation, purification, fragmentation and cloning of genomic DNA; cDNA Library - extraction and purification of mRNA and production of cDNA.
19. Histochemistry**:** Histochemical localization of metabolites:- Starch, proteins, lipids, total carbohydrates, lignin, polyphenols, nucleic acid, histones, cutin, suberin and waxes. Localization of enzymes: Peroxidase, acid phosphatase and succinic dehydrogenase.
20. Ultra structural cytochemistry:- Localization of tannin, protein, cell wall polysaccharide, lignin and membrane.

Practicals

1. Micrometry
2. Maceration techniques
3. Electrical conductivity and pH measurements
4. Quantitative estimation of chlorophyll content using spectrophotometer
5. Absorption spectra of BSA/DNA and determination of absorption maxima
6. Gel filtration
7. Microtomy- Processing, double staining, sectioning
8. Use of Camera Lucida
9. Separation of leaf pigments by paper chromatography and TLC
10. Immunodiffusion technique for testing of antigens and antibodies
11. Rocket immunoelectrophoresis
12. Separation of isozymes by native polyacrylamide gel electrophoresis
13. Microtomy- Processing, double staining, sectioning
14. Histochemical localization of Polysachharides, Total proteins, DNA
15. Preparation of stained permanent slides of the following:
    Whole mounts, free hand sections, maceration and serial microtome sections using double, triple, and histochemical staining procedures. At least 15 permanent micropreparations representing whole mounts, free hand sections and serial sections should be submitted for evaluation

Module – 2 RESEARCH METHODOLOGY

1. Introduction **–** (i) Need for research (ii) Stages of research **–** (a) Definition of a problem (b) Execution of work (c) Interpretation of research; (iii) Methods **–** (a) Technical (b) Logical; (iv) Logical methods **–** (a) Description and classification (b) Evolutionary (c) Determination of casual function **–** Inductive methods (1) Method of difference (2) Method of concomitant variation (3) Method of residue 4) Method of agreement, Statistical methods, Deductive inductive method; (v) Relevance and assumptions

2. Review of literature – (A) Library: (i) Structure of a scientific library – journals – current and back volumes, Books – reference and issues, periodicals and other sources (ii) Catalogue – what is a catalogue and how to use it? Types of catalogues – card catalogue, holdings, computerized catalogue (iii) Classification of books Universal decimal system; (B) Journal (a) Indexing journals (b) Abstracting journals (c) Research journals (d) Reviews; (C) Other sources: (a) Reprints – Acquisition & Filing (b) CD Rom (c) Internet, world wide web (d) INSDOC Services; (D) Preparations for review: (a) Outline of review (b) Selection of key words (c) Preparation of index cards – author index & Subject index.3.
3. Preparation of project proposal – (a) Title and abstract (b) aim and scope, (c) Present status, (d) Location of experiments (e) Materials and methodology, (f) Date of commencement (g) Estimated date of completion, (h) Estimation cost.
4. Preparation of a dissertation (a) Consolidation and analysis of data, photographs, illustration, tables and graphs, (b) Preparation of the outline, (c) Preparation of manuscript – introduction, review of literature, materials and methods, results, discussion, summery, acknowledgements, references; (d) language text tense, capitalization, italics, punctuation, proof reading, abbreviation (e) Bibliography – methods of citing references, arrangement of references (f) Presentation – Title page, certificates, binding, (g) Presentation of research findings in seminars and workshops – OHP, Slides, Computer assisted (power point).

Practicals

1. Preparation of a project proposal and its presentation in the class with the help of OHP.
2. Critical examination of a model dissertation with special reference to citation and listing of references.
3. Critical examination of a model research paper from the perspective of a journal editor.
4. Preparation of a review article on any selected topic.

References:

1. Sharma B.K. 2013. Instrumental method of chemical analysis. Krishna Prakashan Media.
2. Skoog D.A. 2007. Instrumental methods of analysis, 6th edition. Cengage Learning.
3. Plummer. 1987. An introduction to practical Biochemistry. McGraw-Hill.
4. Chatwal G.R. and Anand S.K. 2011. Instrumental Methods of Chemical Analysis. Himalaya Publishing House.
5. Boyer R.F. 2000. Modern experimental Biology. Prentice Hall.
6. Sadasivam, S. and A. Manickam1996: Biochemical Methods. 2nd edition. New Age International (P) Ltd. New Delhi.
7. Voet, D., J.G. Voet and C.W. Pratt. Fundamentals of Biochemistry. John Wiley.
8. Wilson K. and J. Walker. 2010. Principles and techniques of practical biochemistry and Molecular Biology. Cambridge University Press.
9. Browning D. R. Spectroscopy. McGraw-Hill
10. H. H. Willard *et al.* 1988. Instrumental methods of analysis. D.Van Nostrand Company.
11. Freifelder D. 1982. Physical Biochemistry. W. H. Freeman.
12. Bajpai P. K. 2010. Biological Instrumentation and Methodology: (Tools and Techniques). S. Chand & Co.
13. Krishnakumar, K 1981. An introduction to cataloguing practice, Vikas Publ. House.
14. Parashar, R.G. 1989. Index and indexing systems, Medallion Press.
15. Bercy, R. 1994. The research project, how to write it. Rutledge, London, I16p.

SEMESTER III

PS3CO7 PLANT PHYSIOLOGY, BIOCHEMISTRY AND EMBRYOLOGY

Module – 1 PLANT PHYSIOLOGY

1. Water and plant cells: Water in plant's life, properties. Diffusion and facilitated diffusion. Absorption and short distance transport, pressure driven bulk flow and long distance transport. Osmosis driven by water potential gradient. Water absorption by roots via apoplastic, symplastic and transmembrane pathways. Role of aquaporins. Water movement through xylem. Mechanism and theories of transport. Cavitation and embolism. Soil-plant-atmosphere-continuum; physiology of stomatal function - blue light effect.
2. Plants and inorganic nutrition: Nutrient elements: Classification based on biochemical functions. Physiological roles. Nutrient uptake: interaction between roots and microbes. Ion uptake by roots: diffusion, facilitated diffusion and apparent free space. Apoplastic and symplastic pathways. Membrane potential. Passive and active transport. Transport proteins: carriers, Channels: Voltage dependent K+ channels, voltage gated channels, Calcium channels, Vacuolar malate channels. ATPase activity and electrogenic pumps. Patch clamp studies. Active transport and electrochemical potential gradients,
3. Assimilation of mineral nutrients: Nitrogen and bio-geocycle nitrate assimilation, reduction, biological nitrogen fixation. Symbiosis: nitrogenase activity, assimilation of ammonia; pathways and enzymes - GS, GOGAT and GDH. Importance of phosphorus, iron, magnesium, calcium and potassium assimilation. Energetics of nutrient assimilation, molecular physiology of micronutrient acquisition.
4. Photosynthesis: Light absorption and energy conversion, electron transfer system in chloroplast membranes: ATP synthesis in chloroplast. Photosynthetic carbon reduction, carbon oxidation and photorespiratory cycles. C4 and CAM metabolism. Physiological and environmental consideration of photosynthesis. Distribution of photoassimilates- export. Starch and sucrose synthesis. Allocation and partitioning: Phloem loading and unloading. Concept of osmotically generated pressure flow. Importance of plasmodesmata in symplastic transport.
5. Respiration: Glycolytic reactions: Pyruvate entry into mitochondria and citric acid cycle. Electron transfer system and ATP synthesis. Transporters involved in exchange of substrates and products, ATP synthesis, unique electron transport enzymes of plant mitochondria: external NAD(P)H dehydrogenase, rotenone and cyanide insensitive cytochrome C Oxidases. Interaction between mitochondrial and other cellular components. Metabolites and specific transporters.
6. Growth, differentiation and development: Analysis of plant growth: production of cells, growth velocity profile. Cytological and biochemical events. Differentiation : secondary cell wall formations, multinet growth hypothesis of cell wall. Development: initiation and regulation of development, genes involved in the control of development, role of protein kinases. Types of development: flowering-floral induction, evocation and morphogenesis. Floral organ identity genes. Biochemical signaling: Theories of flowering. Control of flowering-phytochrome, cryptochrome and biological clock. Factors affecting flowering: Photoperiodism and thermoperiodism.

7. Fruit development and ripening: physiology of ripening- cell wall architecture and softening, enzymes involved in biochemical changes.
8. Seed development: deposition of reserves during seed development, desiccation of seeds: hormones involved, desiccation tolerance. Classification of seeds, seed dormancy
9. Germination physiology: Imbibition, germination and reserve mobilization.- metabolism of carbohydrates, lipids, proteins and phytins, physiology of seed dormancy.
10. Plant growth regulators: auxins: biosynthesis, transport, physiological roles. Role in signal transduction pathways. Gibberellin: biosynthesis, physiological roles, signal transduction. Amylase activity in germinating seeds. Cytokinin: biosynthesis. biological role, morphogenesis in cultured tissues; mode of action. Ethylene: biosynthesis, physiological role, commercial uses, and mode of action. Abscisic acid: biosynthesis and metabolism, physiological effects, role in seed dormancy and senescence. Hormonal balance concept.
11. Photoreceptors: Phytochromes - photochemical and biochemical properties, localisation in cells and tissues, phytochrome induced whole plant responses, Ecological functions. Mechanisms of phytochrome regulated differentiation. Signal transduction pathways, role in gene expression. Cryptochromes: blue light hormones photophysiology, effect on stem elongation, gene expression, stomatal opening, proton pumps, phototropism, role of carotenoids.
12. Senescence and programmed cell death: Apoptosis and necrosis. Programmed cell death in relation to reproductive development, and stress response. Genes associated with senescence, metabolism during senescence.
13. Stress physiology: Water deficit and drought resistance, heat stress and heat shock, chilling and frost, salinity stress, oxygen deficiency stress and heavy-metal pollution stress.

Practicals

1. Preparation of molal, molar, normal, and percentage solutions and their dilutions.
2. Determination of moisture content of plant materials,
3. Determination of osmotic potential by plasmolytic method.
4. Analysis of Phosphorus in plant tissues.
5. Separation of plant pigments by paper chromatography.
6. Quantitative estimation of chlorophyll content using spectrophotometry.
7. Measurement of Photosynthesis - Hill Reaction
8. Measurement of Light Intensity and Light Transmission Ratio.
9. Measurement of growth rate using various parameters
10. Demonstration of Amylase activity and gibberellic acid effect in germinating cereal seeds.
11. Regulation of Seedling Growth by Plant Hormones

References:

1. Anderson, J.W. and Boardall, J. 1991. Molecular Activation of Plant cells - An Introduction to Plant Biochemistry. Blackwell Scientific Publishers.
2. Beck, C.B. 2005. An Introduction to Plant Structure and Development. Cambridge University Press.
3. Bewley, J.D. and Black E. 1994. Seeds: Physiology of Development and Germination. 2nd Edn. Plenum Publishing Corporation.
4. Bidwell, R.G.S. 1979. Plant Physiology. 2nd Edn. Macmillan Publishing Corporation.

5. Buchanan, B.B., Gruissem, W. and Jones, R.L. 2000. Biochemistry and Molecular Biology of Plants. American Society of Plant Biologists.
6. Devlin, R.M. and Witham, F.H. 1986. Plant Physiology. 4th Edn. CBS Publishers & Distributers.
7. Hopkins, W.G. 2004. Introduction to Plant Physiology. John Wiley & Sons Inc.
8. Karp G. 1996. Cell and Molecular Biology – Concepts and Experiments. John Wiley & Sons, Inc.
9. Mayer and Poljakoff- Mayber. 1989. The Germination of Seeds. 4th Edn. Pergamon Press.
10. Moore. T.C. 1981. Research Experience in Plant Physiology. A Laboratory Manual. Springer Verlag,
11. Noggle, G.R. and Fritz G.J. 1992. Introductory Plant Physiology. Prentice Hall of India Pvt. Ltd.
12. Salisbury, F.B. and Ross C.W. 1992. Plant Physiology. 4th Edn. Wordsworth Publishing Corporation.
13. Steward, F.C. Plant Physiology – A Treatise. Vol. I to X. Academic. Press.
14. Stumpf, P.K. and Conn, E.E. 1980. The Biochemistry of Plants: A Comprehensive Treatise. Academic Press.
15. Taiz, L. and Zeiger, E. 2002. Plant Physiology. The Benjamin Cummings Publishing Corporation Inc.
16. Wilkins, M.B. 1984. Advances in Plant Physiology. Longman Scientific & Technical.

Module – 2 BIOCHEMISTRY

1. Introduction, History, Significance of Biochemistry, Biomolecules.
2. Carbohydrate: mono-, di-, oligo- and polysaccharides, linear and ring structures, homo- and heteroglycans, artificial sweeteners, structure and function of major homo- and heteropolysaccharides, metabolism of starch, cellulose and glycogen. glycoproteins and proteoglycans, biosynthesis of peptidoglycan, metabolic mill.
3. Amino acids and proteins: amino acids – classification, properties, optical activity, unusual aminoacids, classification and conformation proteins, Ramachandran plot, structure, function, mechanism and allosteric regulation of haemoglobin, abnormal haemoglobin, structure and function of leghaemoblobin, Brief account on the biosynthesis of protein.
4. Enzymology – structure, function and classification of enzymes, coenzymes, substrate specificity, regulation of enzyme activity, enzyme kinetics, Michaelis- Menten constant, active sites, inhibitors, allosteric enzymes, kinetics, negative and positive co-operativity, multienzyme, isoenzymes, ribozyme, abzyme, detailed study of FAS and Rubisco, .
5. Lipids – classification, brief account on compound and derived lipids with examples, classification of fatty acids, biosynthesis of fatty acids (microbes, plants and animals), alpha, beta and omega oxidation of fatty acids, omega fatty acid and functional food, trans-fatty acids and their dangers, detailed study of coconut oil.

Practicals

1. Detection of non-reducing sugar in the presence of reducing sugar.
2. Quantitative estimation of reducing sugar from plant tissue by any suitable method.
3. Extraction and estimation of starch from plant tissue by a suitable method.
4. Colorimetric estimation of protein by Biuret method.
5. Colorimetric estimation of protein by Lowry *et al*. method.
6. Measurement of amylase/invertase/protease from any suitable plant/microbial source using suitable method.

7. Determination of Substrate saturation and Michaelis-Menten curve of any enzyme.
8. Paper chromatographic separation of sugars.

References:

1. Alberghina, C. 2000. Protein Engineering in Industrial Biotechnology. Harwood Academic Publications.
2. Berg, J. M., Tymoczko, J.L., & Stryer L. 2006. Biochemistry (6th Edn). WH Freeman & Co.
3. Daniel, M. 1989. Basic Biophysics for Biologists. Agro-Botanica Publishers and Distributors.
4. Delves, P., Martin, S., Burton, D. & Roitt, I. 2008. Roitt's Essentials of Immunology (11th Edn). Blackwell Publishing.
5. Voet, D.J. & Voet, J.J. 2005. Biochemistry (5th Edn). John Wiley & Sons
6. Glaser, R. 2001. Biophysics (5th Edn). Springer.
7. Hammes, G.G. 2005. Thermodynamics and Kinetics for Biological Sciences. John Wiley & Sons Inc.
8. Jain, J.L., Sanjay, J. & Nithin, J.S. 2006. Fundamental of Biochemistry (6th Edn). S. Chand & Co. Ltd.
9. Kindt, T.J., Goldsby, R.A. & Osborne, B.A. 2008. Kuby Immunology (6th Edn). WH Freeman and Co.
10. Lewin B. 2008. Genes IX. Pearson Educational International.
11. Nelson, D.L. & Cox, M.M. 2008. Lehninger Principles of Biochemistry (4th Edn). W.H. Freeman and Co.
12. Pandey, A., Webb, C., Soccol, C. & Larnche, C. 2007. Enzyme Technology. Springer.
13. Rao, C.V. 2005. Immunology: A Text Book. Narosa Publishing House.
14. Sambrook, J. & Russel, D.W. 2008. Molecular Cloning – A laboratory manual (5th Edn). Cold Springer Harbor Laboratory Press.
15. Upadhay, A., Upadhay, K. & Nath, N. 2008. Biophysical Chemistry – Principles and Techniques. Himalaya Publishing House

Module – 3 EMBRYOLOGY

1. History and development of angiosperm embryology.
2. Microsporogenesis: Structure and function of wall layers, ultra structural changes in tapetum in pollen development.
3. Male gametophyte: Microspore/pollen mitosis, division of generative cell heterogenicity in sperms, pollen fertility and sterility, pollen storage, viability and germination.
4. Ovule: Ontogeny, types and evolution, reduction, nutrition.
5. Megasporogenesis: Subcellular features of archesporial and megaspore mother cells, megaspore tetrad, dyad and coeno megaspore, termination of functional megaspore.
6. Embryo sac: Classification and types, ultra structure of components; synergid and antipodal haustoria, nutrition of embryo sac.
7. Pollination: Ultrastructural histochemical details of style and stigma, significance of pollen-pistil interaction, role of pollen wall proteins and stigma surface proteins, intra-ovarian pollination and in vitro fertilization.
8. Fertilization: Role of synergids, filiform apparatus, heterospermy, differential behavior of male gametes, syngamy and triple fusion, post fertilization metabolic and structural change in embryo sac.
9. Endosperm: Classification and types, ultrastructure, cellularisation in nuclear endosperm, endosperm haustoria, their extension and persistence, function, storage metabolites.

10. Embryo: Polarity in relation to development, classification and types, Histo- and organogenesis of mono- and dicot embryos, delayed differentiation of embryo structure, cytology and function of suspensor, physiological and morphogenetic relationship of endosperm and embryo.
11. Polyembryony: Classification and types.
12. Apomixis: Diplospory — apospory, parthenogenesis of embryos.
13. Fruit and seed: Parthenocarpy — induction of seedless fruits.
14. Embryology in relation to taxonomy.
15. Experimental embryology: Embryo culture, anther culture, ovary culture.

Practicals

1. Preparation of dissected whole mounts of endothecium, tapetum, ovule, endosperm, embryo and haustoria. Squash preparations of tapetum, microspore mother cells, dyads, tetrads, pollinia and massulae.
2. Study from permanent preparations — Development and structure of anther, pollen, ovule, megasporogenesis, embryo sac, endosperm and embryo. The comparative study of typical monocot and grass embryos.
3. Pollen germination—viability tests.
4. Intra-ovarian pollination.

References:

1. Bouman F. 1978. Ovule initiation, ovule development and seed coat structure in angiosperms. Today and Tomorrow publishers, New Delhi.
2. Bhojwani 5.5. and Bhatnagar 5.5. 1974. The embryology of angiosperms. Vikas publication, New Delhi.
3. Davis C.L. 1965. Systematic embryology of angiosperms: John Wiley, New York.
4. Eames A.J. 1960. Morphology of angiosperms. McGraw Hill. New York.
5. Johanson D. 1950. Plant embryology, Waltham, Massachusetts.
6. John B.D. (ed) 1984. Embryology of angiosperms. Springer Verlag, Berlin.
7. Maheswari P. 1950. An introduction to the embryology of angiosperms. McGraw Hill, New York.
8. Raghavan V. 1976. Experimental embryogenesis in plants, Academic Press, New York.
9. Wardlaw C.W. 1976. Embryogenesis in plants. Methusen, London.

PS3CO8 BIOTECHNOLOGY AND BIOINFORMATICS

Module – 1 BIOTECHNOLOGY

1. Plant Tissue Culture: General technique, Laboratory and equipments, aseptic techniques, nutrient medium. Morphogenesis, Plant regeneration, Callus, induction, transfer – subcultures, growth kinetics, cell suspension, somatic embryogenesis, advantages, synthetic seeds application.
2. In vitro Production: Micropropagation, cloning, various stages, applications, pathogen indexing, meristem culture, advantages, Haploids, androgenesis, pathways, factors affecting, advantages – applications, gynogenesis, Phytochemicals, large scale cultures, bioreactors, improvement – elicitors, hairy root cultures, biotransformation, and applications.
3. Plant Improvement**:** Somatic hybridization, protoplast isolation, culture, fusion, advantages. Somaclonal variation, origin, advantages
4. Complementary Techniques: Germplasm conservation, slow growth, cryopreservation (freezing – thawing), cryoprotectants, and applications.

Distant hybridization, in vitro pollination/ fertilization, embryo culture, embryo – rescue, applications.

5. Genetic Engineering: Tools used in genetic engineering:
   i. Cloning vectors (plasmid and bacteriophage vectors, cosmids BAC andYACs.
   ii. Enzyme (restriction endonucleases, exonucleases, polymerases, reverse transcriptase, alkaline phosphatase, polynucleotide kinase, Ligases, terminal transferases, topoisomerase, DNA methylase)
   iii. DNA cloning, preparation of plasmid DNA, Restriction and electrophoresis, ligation, transformation and analysis of recombinants.
6. Plant Genetic Engineering**:** Methods of direct and indirect gene transfer in plants, *Agrobacterium*, Ti and Ri plasmids, application of genetic engineering, transgenic plants for insect, fungal, bacterial disease resistance, lignin, modification, abiotic stress tolerance, production of useful products.
7. Techniques of Genetic Engineering**:** Principles and methods of Genetic Engineering, Gene libraries and cDNA libraries (mention only), Polymerase chain reaction (mention only), DNA fingerprinting, DNA Synthesis, DNA sequencing, blotting techniques (mention only), RAPD (mention only), RFLP (mention only), Restriction mapping.

Practicals

1. Preparation of culture medium (MS, N & N, SH, B5 and Whites), sterilization and inoculation methods.
2. Shoot multiplication, Callus culture and organogenesis of important crops/medicinal plants/ornamentals.
3. Demonstration of Agarose gel electrohoresis.
4. Encapsulation of seeds/embryos in calcium alginate.
5. Genomic DNA isolation by CTAB method from plant tissues.
6. Estimation of DNA concentration by Spectrophotometric method.
7. Estimation of RNA concentration by Spectrophotometric method.
8. Students have to submit a record of the above work done.

References:

1. Chawla, H. S. 2002. Introduction to Plant Biotechnology. Science Pub, USA
2. Bhojwani, S.S. 1996. Plant Tissue Culture: Application and Limitations. Elsevier Science Publishers, New York, USA.
3. Vasil, I.K. and Thorpe, T.A. 1994. Plant Cell and Tissue Culture. Kluwer Academic Publishers, the Netherlands.
4. Shantharam, S. and Montgomery, J.F. 1999. Biotechnology, Biosafety and Biodiversity. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi.
5. Glick, B.R. and Thomson, J.E. 1993. Methods in Plant Molecular Biology and Biotechnology. CRC Press, Boca Raton, Florida.
6. Glover, D.M. and Hames, B.D. (Eds.), 1995. DNA Cloning 1: A Practical Approach; Core Techniques, (2^{nd} edition). PAS, IRL Press at Oxford University Press, Oxford.
7. Hackett, P.B., Fuchs, J.A. and Messing, J.W. 1988. An introduction to Recombinant DNA Techniques: Basic Experiments in Gene Manipulation. The Benjamin / Cummings Publishing Co., IncMenio Park, California.
8. Shaw, C. H. (Ed.), 1988. Plant Molecular biology: A Practical Approach. IRL Press, Oxford.
9. Razdan M K. 2003. An introduction to plant tissue culture – Science Pub, USA
10. Glick, B.R., Pasternak, J.J., Patten C.L.2010. Molecular Biotechnology: Principles and Applications of Recombinant DNA**.** ASM Press.

11. Glick, B.R. and Pasternak J.J. 2003. Molecular biotechnology: principles and applications of recombinant DNA. ASM Press.

Module – 2 BIOINFORMATICS

1. Introduction to Bioinformatics: Overview, Internet and bioinformatics, Applications
   Databases: Databases in Bioinformatics, various biological databases, Protein and Nucleotide sequence Data bases. Protein sequence, structure and Classification databases GenBank, DDBJ,EMBL, PIR, PDBSUM, PDB Lite, MMDB, SCOP, Pfam; Database of structure viewers. NCBI, Pubmed, OMIM, Medical databases, KEGG, EST databases. Sequence analysis: Pairwise alignment, local and global alignment, Scoring matrices PAM, BLOSUM, multiple sequence alignment, tools for sequence alignment, programming algorithms, Database similarity searching, FASTA, BLAST, CLUSTALW
2. Gene prediction: Gene structure in Prokaryotes and Eukaryotes, Gene prediction methods: Neural Networks, Pattern Discrimination methods, Signal sites Predictions, Evaluation of Gene Prediction methods. Tools- GENSCAN, GENEFINDER
   Transcriptomics: Complete transcript cataloguing and gene discovery- sequencing based approach, Microarray based technologies and computation based technologies.
   RNA secondary structure prediction.
3. Protein Computational Biology: Structural classification of proteins, Protein structure analysis, structure alignment and comparison, Secondary and tertiary structure prediction and evaluation, prediction of specialized structures, Active site prediction, Protein folding, Protein modeling and drug design.
   Tools in Bioinformatics: Protparam, Translate, Bioedit, findmod, Coils, TMHMM, Rasmol, Deepview, Pymol, Usage of visualization tools
4. Genomics: Comparative Genomics &Functional genomics
   Proteomics: Types of proteomics, tools for proteomics- separation and isolation of proteins, acquisition of protein structure information, databases and applications
   Phylogenetic analysis: molecular basis of evolution, Phylogenetic trees & different methods for phylogenetic inference, Phylogenetic software (CLUSTALW, PHYLIP)
5. Emerging areas of bioinformatics: Scope and applications of Bioinformatics in modern biology, Drug designing, In Silico biology, DNA microarrays, Pharmacogenomics, Medical informatics.

Practicals

1. Exercises on Windows, Linux, UNIX, Networking, Internet search & Graphics.
2. Usage of Software for identification - Accessing existing databases on the World-wide Web; Software for identification of species;
3. Usage of software to elucidate structure of biomolecules, docking of molecules & molecular designing/modelling; Analytical software related to Genomics and proteomics.
4. Usage of similarity, homology and alignment software; Software for Microarray analysis – design, processing and analysis.

References:

1. Bioinformatics: A Beginners Guide. Claverie and Notredame, 2003, Wiley India
2. Bioinformatics: Sequence and Genome Analysis. David Mount, 2013, Cold Spring Harbor Laboratory Press.
3. Bioinformatics: Methods and Applications. S. C. Rastogi, Namita Mendiratta, Parag Rastogi, 2008, Prentice-Hall.
4. Introduction to Bioinformatics. Arthur M. Lesk, 2002, Oxford University Press

5. Bioinformatics: Principles and applications. Ghosh and Mallick, 2008, Oxford University Press India.
6. Bioinformatics: Genes, Proteins and Computer. Orengo, C.A., Jones, D.T., Thornton, J.M. 2004, BIOS Scientific Publishers.
7. Protein Structure Prediction: Methods and Protocols. D. M. Webster, Southern Cross Molecular Ltd., Bath, UK.

PS3CO9 ANGIOSPERM MORPHOLOGY, SYSTEMATICS AND PHYTOGEOGRAPHY

Module – 1 ANGIOSPERM MORPHOLOGY

1. General concepts of morphology, origin and evolution of flower, co-evolution of lowers vis-a- vis pollinators.
2. Origin and evolution of monocot and dicot flowers.
3. Evolution of carpels: Different types of carpels, concepts of foliar origin of carpels alternative concepts and approaches.
4. Specialized carpels – poly and syncarpy – superior, semi-inferior and inferior ovary-appendicular and receptacular concepts – evolution of placentation types.
5. Role of floral anatomy in interpreting the origin and evolution of flower and floral parts.

Practicals

1. Preparation of cleared whole mounts of floral parts to show vasculature.
2. With the help of dissections and hand sections, examine
   a) Transmitting tissue/canals in style and stigma.
   b) Different types of ovaries.
   c) Different types of placentation.
   d) Vasculature of androecium and gynoecium in special types of flowers.

References:

1. Eames A.J. 1961. Morphology of Angiosperms. Macmillan Company.
2. Barnard C. 1901. The interpretation of Angiosperm flower. Aust. J. Sci. 24; 64-72.
3. Manilal K.S. 1981. Vascularisation of corolla of Compositae. J. Ind. Bot. Soc. 50: 189-196.
4. Meeuse A.D.J. 1974. Some fundamental principles of interpreting floral morphology. Intl. Biosci. Pub. Hissar.
5. Melville R.A. 1960. New theory of angiosperm flower, Nature: 188 (14418).
6. Purl V. 1952. Inferior Ovary. Phytomorphology, 2:122.
7. Sporne K.R. 1974. The morphology of the Angiosperms. Hutchinson Univ. Press. London.

Module – 2 SYSTEMATICS

1. Taxonomy: Definitions, Objectives, Importance, Scope.
2. Historical development of theories and concepts of plant classification and classificatory systems.
3. Conceptual bases of the classifications of the following: Bentham & Hooker, Engler, Hutchinson, Cronquist, Takhtajan and APG classification.
4. Taxonomic structure, taxonomic hierarchy, taxonomic categories – supraspecific and infraspecific categories; Concept of species, genus and family.

5. Taxonomic characters: Concept of character, character variations and their taxonomic implications.
6. Sources of taxonomic characters: Morphology, Anatomy, Embryology, Cytology, Palynology, Phytochemistry.
7. Modern trends in Plant Taxonomy: Biosystematics, Numerical Taxonomy (Taximetrics), Cladistics, Molecular Taxonomy.
8. Problems in Evolutionary taxonomy: Concept of primitive and advanced characters/groups, monophyly and polyphyly, parallelism and convergence, homology and analogy.
9. Practical identification of plants: Different kinds of Identification keys, Construction of dichotomous keys – Indented and bracketed keys.
10. Various kinds of Taxonomic literature: Floras, Revisions, Manuals, Monographs, Periodicals and Journals.
11. Plant Nomenclature: Brief History on the origin and development of nomenclature; detailed study of the major provisions of the International Code of Nomenclature for Algae, Fungi and Plants (ICN) Major changes from the preceding Code- Effective and Valid Publication, Rule of Priority and its limitations, Typification, Different kinds of types, Author citation, Rejection and retention of names, Conserved names; Nomenclature of hybrids; Nomenclature of cultivated plants. Common technical terms used in Plant nomenclature
12. Methods of plant exploration; Management of Herbaria; Major Herbaria in India and the World; Role of Herbaria in taxonomy. Floristic studies in India; Major centers of taxonomic and floristic studies in India; Organization and functions of the Botanical Survey of India.
13. Botanical Gardens: Role in taxonomy and biodiversity conservation.

Practicals

1. During the course of this study, the student shall get familiar with the local flora.
2. The students should get familiar with the method of dissecting and studying plants in the laboratory, describing them in technical terms, preparing scientific illustrations, constructing artificial keys and identify them based on Bentham and Hooker's system of classification. For this purpose, each student shall work out at least 2 members of each of the following families of angiosperms available in the area: Menispermaceae, Annonaceae, Cruciferae, Polygalaceae, Caryophyllaceae, Tiliaceae, Rutaceae, Rhizophoraceae, Melastomaceae, Aizoaceae, Rubiaceae, Asteraceae, Oleaceae, Apocynaceae, Asclepiadaceae, Gentianaceae, Boraginaceae, Solanaceae, Scrophulariaceae, Pedaliaceae, Acanthaceae, Lamiaceae, Amaranthaceae, Loranthaceae, Euphorbiaceae, Urticaceae, Commelinaceae, Zingiberaceae, Araceae, and Poaceae.
3. During the course of this study, each student shall undertake a field study tour for at least 3 days, under the guidance and supervision of a teacher, at a place ecologically and floristically different from their place of regular study. Each one shall also collect plant specimens for herbarium preparation and shall submit at least fifty, well preserved, correctly identified and labeled herbarium specimens of common weed plants along with the field book and report for evaluation during the course of their practical examination.

References:

1. Cronquist, A. 1988. The evolution and classification of flowering plants. New York Botanical Garden Press.

2. Dahlgren, R.M.T., Clifford, H.T. & Yeo, P.F. 1985. The Families of Monocotyledons. Springer-Verlag.
3. Davis, P.H. & Heywood, V.H. 1973. Principles of Angiosperm Taxonomy. Robert R Krieger Publishing Co.
4. Douglas, E. & Soltis *et al*. 2005. Phylogeny and Evolution of Angiosperms. Sinauer Associates Inc.
5. Harris J. G. & M. W. Harris. 2007. Plant Identification Terminology. Spring Lake Publishing.
6. Hutchinson, J. 1959. The Families of Flowering plants. Oxford.
7. Mc Neill, J. *et al*. 2006. International Code of Botanical Nomenclature (ICBN) (Vienna Code). A.R.G. Gautner Verlag K.G.
8. Janick, J. *et al*. 2002. International Code of Nomenclature of Cultivated Plants. International Society for Horticulture Science.
9. Judith, E.W. 2002. Describing Plant Species. Bishen Singh Mahendrapal Singh.
10. Kitching, I.J. *et al*. 1998. Cladistics – the theory and practice of Parsimony Analysis. Oxford University Press.
11. Naqshi, A.R. 1993. An introduction to Botanical Nomenclature. Scientific Publishers.
12. Radford, E.A. 1986. Fundamentals of Plant Systematics. Harper & Row Publishers.
13. Simpson, M.G. 2006. Plant Systematics. Elsevier.
14. Sivarajan, V.V. 1991. Introduction to the Principles of Plant Taxonomy. Oxford & IBH Publishing Co. Pvt. Ltd.
15. Sneath, P.H.A. & Sokal, R. R. 1973. Numerical Taxonomy. WH Freeman & Co.
16. Stace, C.A. 1989. Plant Taxonomy and Biosystematics. Edward Arnold.

Module – 3 PHYTOGEOGRAPHY

1. Objectives of Phytogeography.
2. Descriptive Phytogeography: Types of plant distribution: Continuous distribution; cosmopolitan, circumpolar, circumboreal or circum-austral, and pantropical; Discontinuous distribution; Theory of land- bridge, theory of continental drift, theory of polar oscillations or Shifting of poles, glaciations. Centers of origin and diversity of plants; Methods of dispersal, migrations and isolation; Theory of area and theory of tolerance. Factors influencing plant distribution; Migration of floras, and Evolution of floras. Floristic regions of the world: Vegetation Zones in relation to latitudes and altitudes; a brief account of the phytochoria of the Indian subcontinent; Endemics: Neo and relics.
3. Geographical Information Systems: definition, fundamental concepts and components of GIS; developments and future trends in GIS.

Practicals

Interpretation of maps, charts and Landsat imageries pertaining to the vegetation distribution and continental drift.

References:

1. Avise, J.C. 2000. Phylogeography. The history and formation of species. Harvard University Press.
2. Brown, J.H. & M. V. Lomolino. 1998. Biogeography. 2nd Edition. Sinauer Associates, Inc.
3. Cox, C.B., Healey, I.N. & Moore, P.D. 1976. Biogeography. An ecological and evolutionary approach. 2nd Edition. Blackwell Scientific Publications.
4. Mac Donald, G. 2003. Biogeography: Introduction to Space, Time and Life. John Wiley & Sons, Inc.

5. Simmons, I.G. 1979. Biogeography: Natural and Cultural. Edward Arnold Ltd.

SEMESTER IV

Elective Course 1

PS4E01 AGROBIOTECHNOLOGY

1. Microbial inoculants: bacterial inoculants - Rhizobacterial inoculants (Nitrogen-fixing bacteria and Phosphate-solubilising bacteria), Fungal inoculants (mycorrhizae and endophytes), Composite inoculants.
2. *Agrobacterium* and Plant Genetic Engineering: *Agrobacterium*-mediated gene transfer and cloning. Types of plant vectors and their use in gene manipulation. Selectable markers for plant transformation *Agrobacterium*-mediated gene transfer, molecular mechanism of T-DNA transfer - based on vector and Ti plasmid; protocol for Agrobacterium-mediated genetic transformation of plants; its success in monocots and dicots with specific examples
6. Biological Nitrogen Fixation- nif genes- structure, transfer prospects. Nitrogenase biochemistry, function, Legume Symbiosis, Symbiotic Nitrogen Fixation, Regulation of nif and nod genes, biochemistry of leg-haemoglobin. Biofertilizers- significance.
7. Green manuring: algae and other biofertilizers; mass cultivation of cyanobcteria biofertilizers; mass cultivation of *Azolla*; endophytic nitrogen fixers.
8. Molecular Aspects of Disease Susceptibility and Resistance: Transposable elements in plants, factors influencing disease resistance and susceptibility.
9. Transgenics: Stress tolerance - Biotic and abiotic - temperature, salinity, drought etc. Pests and insects resistance – viral resistance – development of disease resistant plants by introducing *Bacillus thuringiensis* genes, Bt-cotton. Plantibodies.
10. Crop protection: microbial herbicides, bacterial insecticides, bacterial insecticides; virus insecticides; entomopathogenic fungi.
11. Crop Improvement in India through biotechnology: Rice, wheat, oil seed crops, forage crops, commercial crops, plantation crops, beverages crops, spices and condiments, tuber crops, fruit crops.
12. Biodiesel and biofuel: significance, potent crops for biofuel production, mechanism, transesterification reaction.
13. Agricultural waste management - Waste minimization, utilization of agricultural wastes, Effects of improper waste disposal.
14. Cleaner technologies: Fermentation. Bioremediation - need and scope, Applications - Removal of toxic chemicals from industrial waste water. Biological gas treatment systems (biofilters, biofilms, bioscrubbers). Applications of bioremediation technology – Replacement of petrochemicals, Reversal of global warming, Biodegradable plastics, Reversal of desert formation. Microbial conversion of CO2 to alcohol. Hyper-accumulators: definition, important hyper accumulators, significance. Phytoremediation: definition, types: Phytoextraction, phytostebilization, rhizofiltration; significance

References:

1. Purohit S. S. Biotechnology: Fundamentals and application. Agrobios.
2. Lewin B. Genes. Pearson Educational International.
3. Peter KV. Horticulture Science Series. New India Publishing Agency.
4. Nelson DL & Cox MM. Lehninger Principles of Biochemistry, WH Freeman and Company.

5. Channarayappa. Molecular Biotechnology: Principles and Practices. Universities Press (India) P. Ltd.
6. Sudhir M. Applied Biotechnology and Plant Genetics. Dominant Publishers & Distributors.
7. Gilmartin PM & Bowler C. Molecular Plant Biology. Oxford University Press.
8. Karanth B. Selected Readings in Plant Genetics and Biotechnology. Book Enclave.
9. Ranjan R. Transgenic Plants. Agrobios.
10. Jha TB & Ghosh B. Plant Tissue Culture: Basic and Applied. Universities Press (India) P. Ltd.
11. Piramal V. Molecular Biotechnology. Dominant Publishers & Distributors.
12. Sudhir M. Plant Biotechnology. Dominant Publishers & Distributors.
13. Das H. K. Text Book of Biotechnolgy. (ed). Wiley Dreamtech India P. Ltd.
14. Park, C. 1997. The Environment. Principles and Applications. Routledge London and New York.
15. Aaradhana P.S. (ed.)1998. Environmental Management. Rajat Publications, Delhi.
16. Jeffrey D.W. 1987. Soil Plant Relationship an ecological approach. Croom Helm.
17. Jones H.G. 1983. Plants and microclimate: a quantitative approach to environmental Plant Physiology. Cambridge University Press.

Elective Course 1

PS4E01 BIOETHICS, BIOSAFETY AND INTELLECTUAL PROPERTY RIGHTS

1. Biotechnology and social responsibility, public acceptance issues in biotechnology, issues of access, ownership, monopoly, traditional knowledge, biodiversity, benefit sharing, environmental sustainability, public versus private funding, biotechnology in international relations, globalization and development divide.
   Introduction to bioethics: Social and ethical issues in biotechnology. Principles of bioethics. Ethical conflicts in biotechnology- interference with nature, unequal distribution of risk and benefits of biotechnology, bioethics versus business ethics.
2. Biosafety: Definition of bio-safety, Biotechnology and bio-safety concerns at the level of individuals, institutions, society, region, country and world with special emphasis on Indian concerns. Biosafety in laboratory: laboratory associated infection and other hazards, assessment of biological hazards and level of biosafety. Biosafety regulation: handling of recombinant DNA products and process in industry and in institutions (Indian context).
3. Introduction and the need for intellectual property right (IPR). Patent and kind of inventions protected by a patent. Patent document. Granting of patent. Rights of a patent. Searching a patent. Drafting of a patent. Filing of a patent. Definition of copyright. Aspects covered by copyright. Duration of copyright. Protection of copyright. Distinction between related rights and copyright. Definition of trademark. Rights of trademark. Kinds of signs used as trademarks. Types of trademark. Functions of trademark. Protection of trademark. Registration of trademark. Introduction to geographical indication. Protection of geographical indication. Protection of industrial designs. Protection of new varieties of plants. Overview of Biotechnology and Intellectual Property. Licensing and Enforcing Intellectual Property. Commercializing Biotechnology Inventions.

References:

1. T. M Murray and M.J. Mehlman, Encyclopedia of Ethical, Legal and Policy issues in Biotechnology, John Wiley & Sons 2000.

2. Ajit Parulekar and Sarita D' Souza, Indian Patents Law – Legal & Business Implications; Macmillan India ltd , 2006.
3. B.L.Wadehra; Law Relating to Patents, Trade Marks, Copyright, Designs & Geographical Indications; Universal law Publishing Pvt. Ltd., India 2000.
4. P. Narayanan; Law of Copyright and Industrial Designs; Eastern law House, Delhi, 2010.
5. P.N. Cheremisinoff, R.P. Ouellette and R.M. Bartholomew, Biotechnology Applications and Research, Technomic Publishing Co., Inc. USA, 1985.
6. D. Balasubramaniam, C.F.A. Bryce, K. Dharmalingam, J. Green and K. Jayaraman, Concepts in Biotechnology, University Press (Orient Longman Ltd.), 2002.
7. Bourgagaize, Jewell and Buiser, Biotechnology: Demystifying the Concepts, Wesley Longman, USA, 2000.
8. M.K. Sateesh. Bioethics and Biosafety. I K International Publishing House. 2008.
9. Kathrine H. Madsen, Peter Sandøe. The Bioethics and Biosafety of Gene Transfer. In: Tzfira, Tzvi; Citovsky, Vitaly (Eds.) Agrobacterium: From Biology to Biotechnology. Springer. 2008, pp 677-697.

Elective Course 2

PS4E02 PLANT TISSUE CULTURE

1. Plant cell and tissue culture: introduction, history, scope.
2. Basic aspects of plant tissue culture; totipotency, morphogenesis, differentiation and polarity; different culture media; components; growth regulators; growth retardants; undefined supplements; explants; sterilization; Inoculation; subculturing.
3. Different types of cultures: callus- different types; cell culture; suspension culture- different types; culture methods of single cells; testing of viability of cells; application of cell and callus culture with special reference to medicinal and aromatic plants. *In vitro* morphogenesis, differentiation.
4. Organogenesis- different types; factors effecting; problems related to micropropagation of woody (Medicinal) plants. Different stages of micropropagation, Somaclonal variation and its importance with special reference to medicinal and aromatic plants.
5. Somatic embryogenesis: direct and indirect; Factors effecting; embryo maturation; application. Synseeds and its significance.
6. Production of Pathogen free plants: Different methods; Meristem culture and its importance in commercialization especially of Medicinal and Aromatic plants.
7. Protoplast: Isolation and culture methods; Factors effecting; Somatic hybridization: Different types; Fusion methods. Application with special reference to medicinal and aromatic plants.
8. Haploids: Different types: Androgenesis and gynogenesis, Advantages; Significance in crop improvement with special emphasis on Medicinal and Aromatic plants.
9. Ovary, ovule, endosperm and embryo culture; importance. *In vitro* fertilization (recent advances) and its significance.
10. Secondary metabolites: Different classes; methods of production- factors effecting yield. Biotransformation; Different types with examples. Immobilization: Different approaches: Advantages.
11. Tissue culture in India with special reference to Kerala. Exploitation of medicinal plants of Kerala by Tissue culture.
12. Application of Plant Tissue Culture: Clonal propagation, artificial seed production of hybrids and somaclones, drugs, products, cryopreservation and germplasm storage.

References:

1. Bhojwani, S. S. and Razdan, M. K. 1996. Plant Tissue culture: Theory and Practice. Elsevier.
2. Doods, J. H. and Roberts, L. W. 1985. Experiments in Plant Tissue culture, Cambridge University Press.
3. George, E. F. 1993-96. Plant propagation by Tissue culture-2 vols. Exegetics Ltd.
4. Narayanaswamy, S. 1994. Plant cell and Tissue culture. Tata McGraw Hill Ltd.
5. De, K. K. 1995. Plant Tissue Culture. New Central Book Agency.
6. Razdan, M. K. 1995. An Introduction to Plant Tissue Culture. Oxford & IBH Publishing Co. Pvt. Ltd.

Elective Course 2

PS4E02 HORTICULTURE

1. Fundamentals of horticulture (History, nature and scope of horticulture) Origin of Horticulture – Domestication of plants, definitions – scope and impact of horticulture (importance of horticulture in terms of economy, production and employment generation classification of horticultural crops) – pomology, olericulture, spices and planting, ornamental horticulture, nutritive value and nutraceutical properties of horticultural crops.
2. Factors influencing horticultural crop production : Growth and development – respiration – photosynthesis – seed physiology – dormancy and germination – physiology of flowering, pollination, fruit set, fruit ripening and senescence – factors influencing growth and development – soil, light, temperature, rainfall, humidity, wind.

   Role of plant growth regulators in seed and bud dormancy, juvenility, maturity and senescence, flowering, pollination, fruit set including parthenocarpy, fruit growth, fruit drop and fruit ripening (climacteric and non- climacteric) and fruit colour development, tuber and bulb formation and sex expression and extension of shelf life in fruits, vegetables and flowers. Role of growth regulators in plant propagation.

   Nutrition of horticultural crops – assessment of nutritional requirements based on soil, tissue analysis, and field experiments. Identification of deficiency symptoms of various nutrients and methods of nutrient application. Assessment of irrigation requirements for different horticultural crops and different methods of irrigation. Pruning and training, their objectives and methods. Pollination and fruit set, problems and requirements, flower and fruit drop, stages, causes and remedial measures. Fruit thinning, objectives, advantages and disadvantages. Unfruitfulness, reasons and remedial measures.
3. Methods of propagation of horticultural crops : Introduction, principles and classification of plant propagation methods: Propagation – definitions – seed propagation – merits and demerits – crops propagated through seeds - Factors affecting seed germination and pre-germination treatments and viability tests – vegetative propagation – merits and demerits – cutting, layering, grafting and budding rootstock influence – stock / scion relationship – specialized structures for propagation – micro-propagation, Importance of micro propagation of plants. Role of growth regulators in propagation.
4. Method of production and cultivation : Definition and nature of growth of fruits, vegetables, spices, plantation and flower crops – system of cultivation and planting systems including HDP for fruits, vegetables, spices and plantation and flower crops – intercultural operations – weed, water and fertilizer management – bearing habits –

crop regulatory practices for fruit crops and vegetables – training, pruning, canopy management – off season production in fruits, vegetables and flower crops – protected cultivation- Principles of protected cultivation, Structure and types of green houses, Regulation of controlled environment (RH, temperature and ventilation) and nutrient management. High-tech nursery raising technology, Production technology of high value vegetables like Bitter gourd, Capsicum, Pea and flowers viz. Rose, Carnation, Gerbera, Lilium, Chrysanthemum. Soil and media, Plant protection, harvesting, grading and packaging.

Importance, scope and practicing of organic farming in horticultural crop production

5. Pre and Post-harvest operations and Technologies of horticultural crops :Crop loading – pre-harvest operations – maturity indices – harvesting methods for climacteric and non-climacteric fruits – grading – sorting – standards for domestic and export consumption (HACCP) – packing – pre-cooling – storage – transport – quarantine and regulatory measures.

References:

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Elective Course 3

PS4E03 MICROBIAL AND PLANT BIOMASS PRODUCTION AND UTILIZATION

1. Production of Microbial Biomass

Microorganisms Used for Biomass Production: Yeasts, Bacteria, Fungi, Algae; Selection and Improvement of Strains; Characteristics of Single-Cell Biomass: Composition, Nutritional Value and Toxicological Status. Physiological Aspects: Growth Parameters, Specific Growth Rate, Substrate Uptake, Biomass Yields. Physical and Chemical Parameters: pH, Temperature, Aeration. Nutritional Requirements of Microorganisms: Substrate, Macro Elements, Production of Microbial Biomass, Trace Elements, Growth Factors, Improvement of Medium Composition for Biomass Production. Types of Biomass Production: Batch Culture, Continuous Culture; The Principle of the Chemostat; Specific Growth Rate; Relation

Between Biomass and Limiting Substrate; Critical Dilution Rate; Advantages of Continuous Culture over Batch Fermentation; Fed-Batch Culture: Change of Input Flow Change in Culture Volume, Change in the Concentration of Limiting Substrate; Mixed Cultures, Competition for a Single Limiting Substrate; Coexistence of Strains on Different Substrates, Complex Interaction Between Strains. Examples of Biomass Production: Carbohydrate Substrate: Molasses, Whey, Starch; Non-Carbohydrate Substrates: Lipids, Methanol, Alkanes, Carbon Dioxide. Biomass production from lignocellulosic substrate: Mushroom production - Raw materials for mushroom cultivation: logs, wood chips, paper products, cereal straws, grain hulls, sugar cane bagasse, banana fronds and other agro-wastes. Supplements added to substrate to enhance yields: corn meal, rice bran, oatmeal and bran, wheat grain and bran. Biological efficiency of mushroom production. Protocol for cultivating mushrooms on agricultural wastes.

2. Plant biomass as an important renewable source of biofuels. Reasons for renewed interest in plant biomass as an energy source. Different types of Plant Biomass. Lignocellulosic matter in plant biomass. Choice of plant species. Biomass properties. Harvesting. Energy production. Factors determining plant biomass yield; Ethanol production from plant biomass. Case study – *Jatropha*, forest based oil seed plants. Multipurpose trees Types, cultivation, harvesting and utilization. Fuelwood, timber, nitrogen fixing trees.
3. Plant biomass production using in vitro techniques, Culture systems, Growth of callus and suspension cultures. Micropropagation: Stages of micropropagation; Factors affecting micropropagation; Multiplication rates and field trials. Plant cell culture technologies as a possible tool for both studying and producing plant secondary metabolites. Specific processes designed to meet the requirements of plant cell and organ cultures in bioreactors. Recent advances in plant genetic engineering to reduce biomass conversion costs: developing crop varieties with less lignin, crops that self-produce cellulase enzymes for cellulose degradation and ligninase enzymes for lignin degradation, development of plants that have increased cellulose or an overall biomass yield.

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Elective Course 3

PS4E03 PHYTORESOURCES, PHYTOCHEMISTRY AND PHARMACOGNOSY

1. Phytoresources: Origins of agriculture, World centers of primary diversity of domesticated Plants; Origin, evolution, botany, cultivation and uses of food, forage-fodder fuel, fiber, furnishings, flavours, medicinal plants, and oil-yielding plants of Kerala and India. Non-wood forest products (NWFPs): Raw materials for paper-making, Gums and Resins, Dyes.
2. Ethnobotany and Conservation History and development of Ethnobotany: Development of Ethnobotany in Asia with special reference to that in India. Traditional Scientific knowledge: Indigenous technical knowledge (ITK): Indigenous Agricultural knowledge (IAK), Traditional ecological knowledge (TEK), Rural people's knowledge (RPK), Traditional botanical knowledge (TBK), Integrated knowledge system (IKS), Basic methods and approaches to study traditional knowledge: Utilitarian, Cognitive, and Ecological.
3. Major tribes of Kerala and their dependence on plants, Scope of tribal medicines, collection of voucher specimens, verification, screening and potential applications
   Problems associated with loss of biodiversity; sustainable utilization of phytoresourses; Conservation, principles, strategies, *in situ* and *ex situ* approaches, protected areas, gene banks and seed banks, international/ national initiatives.
4. Phytochemistry and Pharmacognosy : Extraction, isolation and structural elucidation of natural products; chromatography techniques. Secondary metabolites, types – polyphenols, phytosterols, alkaloids, saponins, terpenes, glycosides; characteristics, extraction strategies, analysis, biosynthetic pathways and inter relationships Pharmacognosy, morphology (macro and micro), methods, detection of adulterants, quality control of ayurvedic and herbal medicines; constituents of drugs, drug synergism and drug interactions
5. Importance and scope of medicinal plants; classification of medicinal plants; cultivation of medicinal plants; processing and utilization; storage of raw drugs; quality and evaluation; tropical medicinal plants: medicinal herbs, medicinal shrubs, medicinal climbers and medicinal trees. Ayurvedic drugs derived from whole plants, underground parts, leaves, flowers, fruits and seeds. Common adulterants used. Detailed study of medicinal plants used in ayurvedic medicines with special reference to *dasamoola, triphala*, and *nalpamara* groups of ayurvedic drugs.

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