Goa University

P.O. Goa University, Taleigao Plateau, Goa 403 206, India

Syllabus of M.Sc. (Botany) Programme

Implemented from the Academic Year 2012-13

A brief description of the course

- **Purpose:** The programme aims at strengthening the fundamentals learnt in under graduate programme and learning new approaches for application of botanical knowledge in human welfare. The students are trained in application of technological tools in unraveling the mystery of evolution, understanding phylogeny, identification and understanding of diversity, using the knowledge in bioprospecting, crop improvement, wasteland reclamation, etc. The knowledge and training imparted helps the students in pursuing further studies in best of the laboratories or if interested in direct application in the field.

- **Prerequisites**: B. Sc. Botany with minimum of 40% marks in the qualifying examination. Students with Botany as one of the subjects at least at the First and Second year of B.Sc are also considered.

- **Credits** (theory, tutorials, practicals): A total of 80 credits out of which not more than 40 credits are core courses and remaining are optional courses. Students may also opt for up to 20 credits from other departments. Core courses have in-built practicals. Most of the optional papers offered in the department are also having in-built practicals.

- **Number of semesters, how the courses are distributed:** M.Sc. course is for two years, i.e. 4 semesters. Students can take 20 or more credits in each semester but at the end it should be minimum of 80 credits to get the degree.

- **Dissertation:** In Botany dissertation is encouraged in lieu of 8 credits in the second year. The dissertation is spread over third and fourth semesters. Students are also encouraged to publish research papers based on their dissertation work.

- **Field work, etc.:** Field work is an essential part of Botany programme though it is not made mandatory.

M. Sc. (Botany) List of Courses

In the following tables, L refers to lectures, T to tutorials and P to practicals. Description of a course appears on the page number listed in the tables.

Compulsory Courses

Course Number	Course Title	L-T-P (hours/week)	Credits	Page no.
BOC-101	Algae, Bryophtes, Pteridophytes Gymnosperms	3-0-3	4	4
BOC-102	Fungi, Bacteria Viruses & Plant Pathology	3-0-3	4	5
BOC-103	Taxonomic methods and classification of Angiosperms	3-0-3	4	7
BOC-201	Internal Morphology & Developmental Biology:	3-0-3	4	10
BOC-203	Advanced Ecology	3-0-3	4	12
BOC-204	Fungal Biodiversity, Bioprospecting and	3-0-3	4	14
BOC-205	Plant Physiology	3-0-3	4	16
BOC-301	Plant Molecular Biology	3-0-3	4	18
BOC-302	Plant Genetic Engineering	3-0-3	4	20
BOC-401	Cytogenetics and Plant Breeding	3-0-3	4	22

Optional Courses (a student must choose at least 20 credits from the following)

Course Number	Course Title	L-T-P (hours/ week)	Credits	Page number
BOO-101	Techniques and Instrumentation in Botany	3-0-3	4	24
BOO-102	Bioinformatics and Chemoinformatics	3-0-3	4	25
BOO-103	Enology	1-0-0	1	30
BOO-104	Mine Wasteland management	1-0-0	1	32
BOO-105	Practical course in Plant identification	0-0-3	1	33
BOO-201	Plant Animal Interaction	3-0-0	3	34
BOO-202	Ethnobotany	2-0-0	2	36
BOO-203	Mycological Techniques	3-0-3	4	38
BOO-301	Applied Phycology:Utilization and Management	2-0-3	3	40
BOO-302	Plant Biotechnology	3-0-3	4	43
BOO-303	Mycorrhizal Biotechnology	2-0-3	3	45
BOO-304	Plant Histochemistry	2-0-3	3	47
BOO-305	Horticulture, Landscaping and Gardening	2-0-3	3	49
BOO-401	Fungal Chemistry and Mycoremediation	1-0-3	2	51
BOO-402	Techniques in Photosynthesis and crop productivity	2-0-0	2	53
BOO-403	Phytochemistry	1-0-3	2	54
BOO-404	Glycobiology	1-0-3	2	56
BOO-405	Remote sensing : Techniques and aplication	3-0-3	4	59
BOO-406	Plant Biochemistry	3-0-3	4	61
BOO-DIS	**Dissertation**	0-0-12	8	62

Recommended distribution of Core Courses semester-wise.

Semester	Course Number
Semester-I	BOC-101
	BOC-102
	BOC-103
	BOC-203
Semester-II	BOC-201
	BOC-204
	BOC-205
Semester - III	BOC-301
	BOC-302
Semester - IV	BOC-401

CORE COURSES

BOC-101: Algae, Bryophyta, Pteridophyta and Gymnosperms. Credits 4 (3T + 1P)

Algae : (11)

1. General Introduction to algae; Classification of Algae; Recent trends in the classification of Algae
2. General account of morphology, anatomy, reproduction, life histories, classification, Phylogeny and inter-
relationships, ecological and economic importance of the following
3. Brief account of Cyanophyta (Cyanobacteria)

Bryophyta : (10)

1. Introduction to Bryophyta : General characteristics, classification, ecological and economic importance of Bryophytes
2. Distribution, morphological, anatomical, reproductive studies and comparative account of sporophytes and gametophytes and interrelationships of the following groups:
Hepaticae: Sphaerocarpales, Calobryales, Takkakiales Marchantiales, Jungermanniales, Anthocerotae: Anthocerotales
Musci: Sphagnales, Andraeales Polytrichales, Buxbaumiales Funariales including their fossil relatives

Pteridophyta: (12L)

1. General characters and classification of Pteridophytes , ecological and economic importance of Pteridophyta
2. Comparative account of Psilotales Lycopodiales, Selaginallales Isoetales, Equisetales, Ophioglossales, Marattiales, Osmundales, Filicales, Marsileales and Salviniales
3. Apospory and Apogamy, Heterospory
4. Soral evolution, Fossil Pteridophytes

Gymnosperms: (12L)

General characters and classification of Pteridophytes, Comparative account of morphology, anatomy phylogeny and interrelationship of Pro-gymnospermopsida, Gymnospermopsida and Gnetopsida, Fossil gymnosperms

Practicals: (15)

1. Collection techniques for planktonic, epiphytic, and benthic algae (1P)
2. Preservation of marine algae and preparation of permanent slides for algae (1P)

3,4,5,6. Study of vegetative and reproductive features of important algal groups with the available representatives (4P)

Chlorophyta Charophyta Euglenophyta Chrysophyta
Cryprtophyta , Pyrrhophyta Phaeophyta Rhodophyta

7,8,9. Study of vegetative and reproductive features of important bryophytes groups with the available representatives (3P)

Hepaticae, Anthocerotae and Musci

10,11, 12, Study of vegetative and reproductive features of important Pteridophyta groups with the available representatives: Psilotales Lycopodiales, Selaginallales Isoetales, Equisetales, Ophioglossales, Marattiales, Osmundales, Filicales, Marsileales and Salviniales (3P)

13, 14, 15. Vegetative and reproductive reproductive features of Gymnospermopsida and Gnetopsida with available representatives. Also some paliobotany specimans (3P)

BACK

BOC-102: Bacteria, Fungi, Mycoplasma, viruses and Plant Pathology **4 credits**

FUNGI (15)

Fungi: Introduction; General characteristics; Comparative account of morphology, physiological specialization; asexual and sexual reproduction; evolution and phylogenetic affinities; Structural, functional and ecological specialization of fungal mycelia and spores; Taxonomy and Nomenclature; Morphology and molecular-based taxonomy; Modern trends in classification; Fungal biodiversity.

Study of different groups of fungi with suitable native examples: Slime moulds, Chytridiomycota; Ooomycota; Glomeromycota; Zygomycota; Ascomycota and Basidiomycota; Straminifilan fungi.

Study of economic importance of fungi; Endo- and ecto-mycorrhizae; Orchid mycorrhizae; Edible and poisonous mushrooms; Wood decay by fungi; Lichens; Yeasts; Fungal cultures; Fungal bioprospecting; Secondary metabolites; Industrial significance; Fungi in food processing, production of enzymes, alcohols, antibiotics and pharma- products; Mycotoxins in food and feed; Fungi as biocontrol agents.

BACTERIA: (8)

Morphology and fine structure; Chemical composition of bacterial cell and cell wall; Classification and Nomenclature; Economic importance in relation to biological nitrogen-fixation and production of antibiotics and enzymes. Actinomycetes

MYCOPLASMA: **(2)**

Structure and importance of Mycoplasma and L-forms.

VIRUSES, VIROIDS AND PRIONS: (5)

Morphology, chemical composition, ultrastructure, replication, classification and nomenclature of Plant Viruses; The virus cryptogram; Transmission of Plant Viruses; Virus-Vector relationship; Control of Plant Viruses; Viroids and Prions.

PLANT PATHOLOGY: (15)

A brief history of plant pathology in India. Symptomatology in fungal, bacterial, viral and mycoplasma diseases of plants; Obligate and facultative pathogens. Classification of plant diseases; methods in the study of plant diseases; Koch postulates; Principles of infection and spread of disease; Sources of inoculum; Physiology of host-pathogen interaction; Role of enzymes and toxins in pathogenesis; Molecular basis of plant diseases; Lectins as recognition signals; Susceptability and resistance; Epidemiology, disease cycle, disease forecasting; Control of crop diseases by cultural, physical, chemical and biological methods; Crop rotation; Plant quarantine; Resistant varieties; Algal diseases.

Diseases of cereals, pulses, vegetables, oil-seed crops, fruit plants, and plantation crops; Viruses, mycoplasma, protozoan and nematode diseases; Etiology, epidemiology and management of major diseases of paddy (blast, brown leaf-spot, sheath blight, bacterial leaf blight and tungro Virus), jowar (smut by *Sphacelotheca sorghi* and *S. cruenta*), sugarcane (red rot), groundnut (tikka), cotton (wilt), coconut (leaf blight, wilt, yellowing), banana (leaf spot, bunchy-top), mango (powdery mildew, sooty mould). Post-harvest and market pathology; Seed certification.

PRACTICALS: **(15)**

1. Study of microbiological lab techniques; preparation of agar culture media; Sterilizations techniques: dry and wet;
2. Methods of isolation and culturing of fungi; colony characters; microscopic observations; mounting fluids; morphology of hyphae and spores; reproductive structures of different genera of fungi. Bacterial cultures;
3. Observation of different fungal substrates on sterile moist chamber incubation (e.g. herbivore dung; decomposing leaf-litter); Observations on ecological succession of fungi; Terrestrial, marine and freshwater fungi.
4. Particle-plating, endophyte isolation and serial dilution techniques (e.g. soil, dung and leaf-litter); Qualitative and quantitative estimation of fungi.
5. Collection of infected specimens in the field; Observation of symptoms; Laboratory studies; Hand sections and tease mounts;
6. Study of as many as possible viral, bacterial and fungal diseases of crop plants (cereal, vegetable, fruit, plantation) from surroundings in Goa.
7. Bacterial staining by using simple and Gram stain.
8. Isolation and observation of *Rhizobium* from root nodule of leguminous plant.
9. Observations on enzyme and antibiotic production in fungi.
10. Submission of 10 dried herbarium specimens of infected plant materials [fungal (4)+ bacterial (3) + viral (3)] collected from nearby habitats and 10 pure cultures of different fungi on slants isolated from various substrates.

BACK

BOC-103: TAXONOMIC METHODS AND CLASSIFICATION OF ANGIOSPERMS. 4 Credits

Plant taxonomy: Scope and importance; taxonomy as a synthetic discipline; principles and goals; applications - IUCN Red List, Conservation priorities, new economically important plants including medicinal plants, bioprospecting, new taxa and novel genes. (3)

Floras, Revisions and Monographs: Floras, Revisions and Monographs as basis of taxonomy; components, design and methods of floristics and revisionary/ monographic studies; role of herbaria, botanic gardens and literature in taxonomic studies; important literature resources. (5)

International Code of Plant Nomenclature: Purpose, Principles, and overall knowledge of Articles pertaining to typification, publication, priority, author citation and their application. (5)

Taxonomic characters other than morphology: Characters from anatomy, embryology, palynology, chromosomes, secondary metabolites, proteins, nucleic acids in taxonomy. (8)

Numerical methods in taxonomy: Phenetics, Principal Component Analysis, Discriminant Analyses. (4)

Cladistics: Introduction – advantages and problems; classical taxonomy as base for molecular systematics; systematics and phylogenetic classifications – use and utility. The choice of molecules in systematics – Nucleic acids, proteins and amino acids. Molecular evolution – neutral theory, molecular clock. Cladistics (Phylogeny) – concepts, parsimony, cladograms and trees; characters: apomorphic and plesiomorphic characters, homologous vs analogous; character states, binary and multistate characters, characters transformations; morphometric vs molecular characters. Trees - monophly, polyphyly and paraphyly; rooted and unrooted. Tree construction – algorithmic (UPGMA and Neighbour Joining) and tree-searching (Parsimony, Maximum Liklihood and Bayesian). (6)

Phytogeography: Basic terminologies and their understanding; endemism – types and causes; vicariance; phylogeography and applications; floristic regions of the world (Takhtajan). (4)

Phylogeny and Classification of Angiosperms: Fossil angiosperms and their ecology. APG III system of classification of angiosperms; characteristics and phylogeny of clades: Orders – Amborellales, Nymphaeales, Austrobaileyales, Chloranthales; Clades ((Magnoliids), (Monocots (Commelenids)), Order Ceratophyllales, (eudicots (core eudicots(rosids (malvids, fabids)) (asterids (campanulids, lamids. (10)

Practicals: Taxonomic Methods and Classification of Angiosperms (15)

1. Study of a published Floras, Revision and Monograph; identification, listing and analysis of their components. (1)
2. Botanical illustrations (line drawing) - basic rules regarding proportion, scientific accuracy, scale, numbering and legend. (1)
3. Identification of species and families of locally available angiosperms using Floras, revisions and monographs. Salient features of families to be recorded in Journals (illustrations not required). (5)
4. Arrangement of studied families according to APG III classification. (1)
5. Collection, herbarium preparation and identification of six species of a family / genus available in and around the campus and writing of floristic account including key, nomenclature (with author citation and citation of local/regional Floras), descriptions, phenology, notes, photographs and illustrations (each student should take different family/genus). (5)
6. Construction of phylogenetic tree based on gene sequences available at NCBI database (each student may be given different gene sequences/taxa). (1)
7. Preparation of taxonomic field report based on general field study course. (1)

Recommended books/sources:

APG III, 2009. An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants: APG III. Botanical Journal of the Linnean Society 161: 105 –121.

Barry G. Hall, 2007. Phylogenetic Trees Made Easy: A How-To Manual, Third Edition.Sinauer Associates, Inc., Publishers, Sunderland, USA.

Benson,L.D. 1962. Plant Taxonomy: Methods and Principles. Ronald Press, New York.

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

Davis, P.H. & V.M. Heywood. 1963. Principles of Angiosperm Taxonomy. Oliver & Boyd, Edinburgh.

Douglas E. Soltis, Pamela E. Soltis, Peter K. Endress, & Mark W. Chase, 2005. Phylogeny and Evolution of Angiosperms. Sinauer Associates, Inc., Publishers, Sunderland, USA.

Ian J. Kitching, Peter L. Forey, Christopher J. Humphries & David M. Williams, 1998. Cladistics: The Theory and Practice of Parsimony analysis (2nd Ed.). The Oxford University Press.

Jain, S.K. & R.R. Rao. 1977. A handbook of Field and Herbarium methods. Today and Tomorrow Printers and Publishers, New Delhi.

Joesph Felsenstein, 2004. Inferring Phylogenies. Sinauer Associates, Inc.

Jones, S.B. & A.E. Luchsinger. 1987. Plant Systematics (2nd Ed.) McGrawHill Book Company. New York.

Lawrence, G.H.M. 1951. Taxonomy of Vascular. Plants. Oxford & IBH Publishing Co.

Michael J. Moore, Pamela S. Soltis, Charles D. Bell, J. Gordon Burleigh & Douglas E. Soltis, 2010. Phylogenetic analysis of 83 plastid genes further resolves the early diversification of eudicots. (www.pnas.org/cgi/doi/10.1073/pnas.0907801107)

Michael George Simpson, 2006. Plant systematics. Elsevier Academic Press.

Nei, M. & S. Kumar, 2000. Molecular Evolution and Phylogenetics. Oxford University Press Inc.

Peter Skelton & Andrew Smith, 2002. Cladistics: A Practical Primer on CD-ROM with accompanying booklet by Neale Monks. Cambridge University Press.

Stevens, P. F. (2001 onwards). Angiosperm Phylogeny Website. Version 9, June 2008 [and more or less continuously updated since]. http://www.mobot.org/MOBOT/research/APweb/

Quicke, D.L.J. 1993. Principles and Techniques of Contemporary Taxonomy. Blackie Academic & Professional (An imprint of Chapman & Hall.).

Radford, A.E., W.C. Dickinson, J.R. Massey & C.R. Bell. 1974. Vascular Plant Systematics, Harper & Row, New York.

Robert W. Scotland, Toby Pennington, 2000. (Eds.). Homology and systematics: coding characters for phylogenetic analysis. Systematics Association.

Salemi, M. & A.-M. Vandamme (Eds.) 2003.The Phylogenetic Handbook. A Practical Approach to DNA and Protein Phylogeny. Cambridge University Press.

Singh, G. 2009. Plant systematics: an integrated approach. Science Pub Inc.

Sivarajan, V.V. 1991 (2nd ed.). Introduction to the Principles of Plant Taxonomy (Ed. N S K Robson). Oxford & IBH publishing Co. Pvt. Ltd.

Stace, C.A. 1989 (2nd ed.). Plant Taxonomy and Biosystematics. Edward Arnold.

Stuessy, Tod F., 2009. Plant taxonomy : the systematic evaluation of comparative data (2nd ed.). New York : Columbia University Press.

Takhtajan, A. 1986. Floristic Regions of the World. University of California Press.

Walter S. Judd, Christopher S. Campbell, Elizabeth A. Kellogg, Peter F. Stevens, & Michael J. Donoghue, 2007. Plant Systematics: A Phylogenetic Approach, Third Edition.Sinauer Associates, Inc., Publishers, Sunderland, USA.

BACK

BOC-201: Internal Morphology and Developmental Biology of Angiosperm (3+1)

Internal Morphology

Origin, growth, differentiation and ultra-structure of cells and tissues; fine structure of plasmodesmata, microtubules, microfibrils. (1h)

Cell Walls: Genesis and ultra-structure of cell walls, pits, cell-wall polymers, incrustation and adcrustation of cell walls; symplasm and apoplasm. (2h)

Meristems: Shoot and root apical and intercalary meristems; their ultra-structure and histochemistry; cytological and molecular analysis of the shoot apical meristem; autonomy of the meristem and vascular tissue differentiation in the shoot apex. (3h)

Vascular cambium vs cork cambium, factors controlling their activity; lenticels; abscission; wound healing. (2h)

Ontogeny, phylogeny, evolution, ultra-structure and function of primary and secondary xylem; wood anatomy; bio-deterioration of wood and its prevention. (4h)

Ontogeny, phylogeny, evolution, ultra-structure and function of primary and secondary phloem. (2h)

Structural variability in leaves including leaf structures of C_3 and C_4 sub-types, CAM plants; leaf histogenesis; leaf meristems; evolution of leaf forms, heteroblasty; origin, development and ultra-structure of trichomes and stomata. (3h)

Nodal anatomy: nodal types, phylogenetic and evolutionary considerations. (2h)

Anatomy of monocotyledonous and dicotyledonous seeds and fruits - their ontogeny structure and functions. (2h)

Embryology

Microsporogenesis and formation of the male gametophyte: Anther differentiation, pollen development and maturation, gene expression during pollen development, male sterility and pollen abortion, male gametogenesis. (3h)

Megasporogenesis and formation of embryo sac: Ovule differentiation and development, megasporogenesis, organization of embryo sac, types of embryo sac, gene function during megagametogenesis. (3h)

Pollen pistil interaction and fertilization: Pollen-stigma interaction and pollen tube guidance, pollen recognition by stigma, self-incompatibility, structural, biochemical and molecular aspects of gametophytic and sporophytic self incompatibility. Double fertilization, *in vitro* fertilization. (4h)

Endosperm and embryogenesis: Endosperm, embryo, nutrition and growth of embryo. Gene action during embryogenesis, storage protein of the endosperm and embryo, storage protein gene expression in transgenic systems; apomixis and polyembryony; applied aspects of embryology. (4h)

Palynology

Pollen Biology: Pollen wall features, development and evolution of pollen types, palynology and taxonomy. (3h)

Aeropalynology: Methods of aerospora survey and analysis; pollen allergy and pollen calendars (2h)

Mellittopalynology: Honey bee and pollen loads; role of apiaries in crop production. (2h)

Palaeopalynology: Study of fossil pollens and spores and their significance in paleobotany and coal and oil explorations. (2h)

Pollen biotechnology for crop production and improvement. (1h)

Practicals

1. Comparative anatomy of monocotyledon and dicotyledon root, stem and leaf.
2. Anatomical basis of identification C_3 & C_4 sub types in grasses.
3. Phytoliths of grasses and their potential use in identification.
4. Anatomy of lenticels and periderm in plants.
5. Anatomy of monocotyledonous and dicotyledonous seeds.
6. Study of different types of stomata and trichomes.
7. Maceration of wood to study xylem components.
8. Study of microsporangium and microsporogenesis.
9. Study of megasporangium and embryo sac development.
10. Study of types of endosperm and its modifications.
11. Study of development of embryo in dicot and monocot.
12. Study of different ornamentation patterns in pollen grains by acetolysis.
13. Collection and identification of local aerospora.
14. Analysis of honey samples to identify uni-floral or multi-floral honey.
15. Study of fossil pollen grains and spores.
16. Submission of ten permanent preparations by students at the end of the Semester.

Reference Books

1. Batygina T. B. 2009. Embryology of Flowering Plants Terminology and Concepts, Volume 3, Reproductive Systems, Science Publishers, USA.
2. Raghavan V. 2000. Developmental Biology of Flowering Plants, Springer-Verlag, New York.
3. Bhojwani S. S. and Bhatnagar S. P. 1984. Embryology of Angiosperms, Vikas Publishing House, New Delhi.
4. Johri B.M. 1984. Comparative Embryology of Angiosperms, Ind. Nat. Sci. Acad., New Delhi.
5. Maheshwari P. 1985. An Introduction to Embryology of Angiosperms, Tata McGraw Hill, New Delhi.
6. Fahn. A. 1990. Plant Anatomy, 4th Edition, Pergamon press, New York, Oxford.
7. Eames A. J. & Mac Daniels L. H. 1947. Introduction to Plant anatomy, McGraw Hill, New York.
8. Esau K. 1985. Plant anatomy, 2nd Edition, Wiley Eastern Limited, New Delhi.
9. Metcalf C. R. and Chalk L. 1950. Anatomy of Dicots Vol. I & II, London Press, Oxford.
10. Romberger J. A., Hejnowicz Z. and Hill J. F. 1993. Plant Structure: Function and Development, Springer-Verlag.
11. Endtman G. 1952. Pollen Morphology and Plant Taxonomy: Angiosperms, Almquist and Wiksell. Stockholm
12. Erdtman G. 1966. Pollen Morphology and Plant Taxonomy: Angiosperms, Hafner Publishing Co., New York.
13. Nair P.K.K. Essentials of Palynology, Asha Publishing House, New York.
14. Nair P.K.K. 1966. Pollen morphology of angiosperms, Periodical Expert Book Agency, New Delhi.
15. Nair P.K.K. 1970. Pollen Morphology of Angiosperms A Historical and Phylogenetic Study, Scholar Publishing House, Lucknow.
16. Shivanna, K. R., Sawhney V. K. 1997. Pollen Biotechnology for Crop Production and Improvement, Cambridge University press. U.K.
17. Bio-deterioration of Wood and Its Prevention in Indian Coastal Waters, Institute of Wood Science and Technology, Malleswaram, Bangalore, 1997.
18. Lyndon R. F. 1990. Plant Development, The Cellular Basis. Cambridge University Press, UK.
19. Hesse M., and Ehrendorfer F. 1990. Morphology, Development and Systematic Relevance of Pollen and Spores, Springer-Verlag, New York.

BACK

BOC-203: Advanced Ecology **4 Credits**

Ecology of climate change and development (ECCD):- Climate change-the current picture; multi-disciplinary understanding of climate change processes and of their direct and indirect interactions with development; Climate change and biosphere; ecosystems; biodiversity; diseases, bioinvasion and invasive species; pollution; Climate change and global agriculture; water resources; impact on India's biomes; animal and human populations; Adapting to climate change in 21 st century, efforts for mitigation, Carbon trade, Carbon credits (07)

Chemical ecology (CE) :- Understanding basic terminology such as pheromones, kairomones, allomones , semiochemicals; interactions by chemical substances, i.e. semiochemicals, between animals, plants and environment; Importance of chemical communication in living organisms; the importance in involving structure-activity studies to optimize the bioactivity of chemical substances; sustainable alternatives to the conventional use of insecticides, fungicides and herbicides used in gardening, agriculture and forestry, advantages – disadvantages with biological control methods; important research areas in ecological chemistry, chemical communication; tropical case studies-social insects such as dampwood and mound building termites (07)

Tropical Soil Ecology (TSE)
Classification and characteristics of tropical soils; Soils as a biological habitat, tropical Soil biodiversity; Organic matter decomposition by microbes in oxic and anoxic environments, Soil microbial groups based on metabolism and respiration; Humus formation and humic matter in tropical soils; role and importance of Soil enzymes; Carbon and nitrogen ratios and other factors affecting mineralization and immobilizationof nutrients; tropical Forest soils; Earthworms and composting, soil erosion and soil fertility management (06)

Landscape ecology (LE) :- Historical development, Applications of landscape ecology, Definitions and terminology in LE, Pattern, heterogeneity, patches, Scale and hierarchy on landscapes; Change and long temporal scales; Causes of pattern; Landform and landscape position; Land use- Social and cultural landscapes; The role of disturbance on landscapes-Spatial dynamics of disturbance, Disturbance, equilibrium, and scaled landscapes, Forest landscape succession-Succession as a spatial process , Modeling landscape succession and management, Biodiversity and landscape management,
Landscape restoration, Landscape management: Natural variability, scientific uncertainty, and sustainability; Case studies from India-habitat fragmentation in western ghats, in mining areas etc. phytoremediation , coastal erosion and techniques for coastal stabilization (07)

Urban and industrial ecology- (UIE) Ecology of towns and cities, urban ecosystems; urbanization in tropical countries; sustainable urbanization, Ecological cities, techniques in Conservation of Urban biodiversity and urban forestry; Case studies of model cities and towns e.g. Curitiba-Brazil; Conceptual design of a model urban ecosystem, What is Industrial Ecology?, Environmental Paradigm, Sustainability: Concepts and Metrics, resource economics, Materials flow and Life cycle,assessment (LCA) , industrial ecosystems, case studies e.g. Kalundberg, Thane (07)

Ecological economics (EE), Environmental valuation and auditing (EA) –Basics of EE; Polluter pays principle; Gross national and gross natural products; Natural resources accounting procedure (NRA) ; techniques used in NRA; evaluation of ecosystem services; fundamentals of bioeconomics; Work by costanza and others; How to assess environmental performance of a company or organisation, with appropriate case studies; Importance of EE in national planning and development (06)

Environmental impact assessment (EIA)

History of EIA, EIA, EIS, EMP; EIA laws and regulations, projects requiring EIA in India; EIA methodology-Checklist, overlay, modeling, Network, Matrix, computer assisted; EIA software packages and tools; Biological impact assessment; preparing EIA reports, public hearing procedures; EIA case studies from India (05)

Practicals: (15)

1. Analysis of IPCC data on climate change
2. Using online weather monitoring systems and generating reports-sea level gauges
3. Sampling and analysis of rainwater-for physicochemical and biological/microbiological constituents
4. Detection of chemical trails of ants and termites, Responses of ants and termites to chemicals
5. Analysis of vermicasts for organic matter, micronutrients
6. Analysis of soil humic matter, Detection of soil enzymes using chromogenic substrates
7. Isolation of soil microbiota and assessment of their ecological role
8. Landscape analysis and modeling using software tools
9. Landscape analysis using satellite imagery data
10. Cataloguing urban land use and biodiversity using maps and field data
11. Conceptualizing a model urban ecosystem using design tools
12. Flowcharting an industrial ecosystem
13. Evaluating local ecosystem services using standard equations (Costanza, 1997)
14. Conceptualizing rainwater harvesting system for an industrial estate
15. Performing Rapid EIA using Leopold interaction matrix (different projects)
16. Software for EIA –solid waste management
17. Performing rapid biological impact analysis
18. Use of vetiver grasses for erosion control

Reference and Text books:

Christianson G E (2000) Green House, The 200 year story of Global warming, Universities press, India

- Modak Prasad and Biswas asit k (1999) Conducting environmental impact assessment in developing countries, OUP
- Kadekodi Gopal K (ed). (2004) Environmental economics in practice, Oxford University Press (OUP)
- Lemont C. Hempel (1998) Environmental governance-the global challenge, AEW press
- Herma Vehoef and Peter J. Morin (2010). Community ecology, Processes, models and applications, 2nd edition, OUP
- Mark J. McDonnell, Amy K. Hahs, Jürgen H. Breuste (2009) Ecology of Cities and Towns: A Comparative Approach, Cambridge University Press
- Marcel Dicke and William Takken ed. (2006) Chemical ecology: From genes to ecosystems, springer
- Thomas Eisner, and Jerrold Meinwald (2004) Chemical Ecology: The Chemistry of Biotic Interaction National Academy of Sciences,
- Dietland Müller-Schwarze (2009) Hands-On Chemical Ecology:: Simple Field and Laboratory Exercises
- Inderjit and Azim U. Mallik (2003) Chemical Ecology of Plants, Academic Press

BACK

BOC-204: FUNGAL BIODIVERSITY, BIOPROSPECTING AND BIOTECHNOLOGY. 4 credits

Fungal biodiversity (15 h)

Evolutionary biology and population genetics of fungi; fungal phylogeny; current status of fungal dimension of global biodiversity; inventory and monitoring methods; Fungi in global ATBI; fungi as friends and foes;

Characteristics of diverse fungal habitats; Fungi in terrestrial, marine and freshwater habitats; fungi in tropical ecosystems and extreme environments; Fungi in phyllosphere and phylloplane, Endophytic, rhizosphere and soil fungi; fungal endosymbionts; insect –fungus mutualism.

Post-harvest diseases of perishable and durable produces; market pathology and management; Diseases of nurseries and forest trees; diseases of agro- and farm forestry; fungi as biodeteriorating agents in tropics; economic losses due to fungal decomposition; Soil-born pathogens; nematode-trappers; fungi as human and animal pathogens.

Fungal biodiversity of India. Case studies: fungal biodiversity of Western Ghats, Arabian sea, Indian ocean; fungi from alpine and polar regions.

Present knowledge of research in fungal ecology ; nutritional modes of fungi-saprotrophs, biotrophs and necrotrophs; role of fungi in ecosystem services;

Fungi and global warming, conservation biology of fungal habitats and fungal resources

Fungal bioprospecting (10 h)

Chemically creative fungi; screening for industrially useful fungal metabolites; drugs and pharmaceuticals from fungi; Ecotaxonomic approach in chemical screening; primary and secondary products of metabolism; classification of secondary metabolites; primary and secondary screening of antibiotic producers; auxanography; enrichment culture, techniques for strain improvement and Strain development; Industrial fungal strains; preliminary and high throughput screening (HST); leads and lead optimization, IPR issues and patents

Fungal biotechnology (20h)

Fungal biotechnological processes, Principles of fermenter design and operation, types of fermenters, formulation of fermentation medium, analysis of fermentation products

Biotechnological applications of yeast/fungi and their derivatives during history: bread making, alcohol production, applications in medical science, bioconversion and bio-ethanol .

Production of antibiotics—beta lactam antibiotics-penicillins and cephalospoins, Organic acids-production of citric acid, fungal enzymes and their industrial applications- alpha amylases, cellulases, xylanases, invertase, proteases, Vitamins, pigments, PUFAs; therauptic peptides;

Production and utilization of fungal biomass; fungi as food and feed; Bakers and industrial yeast; production of alchoholic beverages-beer, wines; production of bread and cheese; Edible fungi; Mycoproteins. Advancement in mushroom cultivation technology; Commercial mushroom species; strain improvement and cultivation; tropical mushrooms and their cultivation; mushroom spawns; nutritional aspects of mushrooms.

Fungal biofertilizers and biopesticides , myconematicides

Recombinant technology in yeast and fungi: composition of the different types of fungal vectors, selection markers, transformation strategies, gene replacement or inactivation *S. cerevisiae* as model and screenings organism: complementation, yeast surface display, yeast two-hybrid

Heterologous gene expression/protein production: description of the yeast secretion pathway, post-translational modifications (e.g. glycosylation), how to increase gene expression, examples, applications and future perspectives.

Practicals: **(15)**

1. Fungal biodiversity inventorying methods
2. Testing endophytic fungi for secondary metabolites
3. Screening *Aspergillus* strains for organic acid production
4. Phosphate solubilization assay using Pikovskaya medium
5. Screening yeasts for sugar fermentation capacity
6. Extraction of pigments from fungi
7. Production of amylase using bench top fermenter
8. Partial purification of a fungal hydrolytic enzyme
9. Immobilization of fungal enzymes
10. Bench top production of Penicillin using phenyl acetic acid and peanut meal
11. Production of fruit wines on small scale and their sensory evaluation
12. Production of mushroom spawn and assessment of its' quality
13. Monitoring biotechnological parameters of oyster mushroom cultivation
14. Testing action of fungicides on fungal cultures
15. Testing Dough raising power of Bakers' yeast
16. Tests to detect fungal siderophores

BACK

BOC-205: PLANT PHYSIOLOGY. 4 credits

1. The physico-chemical organisation of the plant cell and cell organelles; structure and composition of plasma membrance fluid mosaic lipo-protein model, surface monolayer, confirmation of lipid in micelles and membranes melting transition; movement of water and substances across the membrane. 2h
2. Water relation of plants, unique physico chemical properties of water; bulk movement of water, aquaporins, stomatal regulation of transpiration, anti transpirants; 2h
3. Inorganic nutrition, macro and micro nutrients, deficiency symptoms, hydroponic studies; mineral absorption and translocation and assimilation; Nernst equation and Donnan's equilibrium. 2h
4. Nitrogen metabolism: Nitrogen nutrition, organic nitrogen, nitrogen fixation in legumes, nitrate and ammonia assimilation: Sulfur metabolism and amino acid synthesis. inter relationship between photosynthesis, respiration and nitrogen metabolism. 3h
5. Photosynthesis: Importance of photosynthesis, Photosynthesis and environment.
6. Light reaction: Radiant energy, photosynthetic apparatus, pigments and their biosynthesis; light harvesting complex; light absorption and composition and characteristics of two photosystems, photosynthetic electron transport, water oxidation and its molecular mechanism, photophosphorylation, pseudocyclic electron transport, Mehler reaction, electron transport in other systems (bacteria). 6h
7. Dark reaction: Carbon dioxide fixation in C3, C4 and CAM plants regulation of PCR cycle; photorespiration and its regulation, environmental factors affecting photosynthesis. 3h
8. Respiration: Aerobic and anaerobic respiration; cyanide independent respiration; fermentation; cytochrome system; carbohydrate and lipid metabolism; high energy compounds and factors affecting respiration. 4h
9. Bioenergetics: Chemiosmotic hypothesis and energy transduction; energy transducing organelles mechanism of ATP synthesis, quantitative bioenergetics. 2h
10. Enzymes: Structure and classification; mechanism of action; Michaelis-Menten equation; Lineweaver-Burk plot; enzyme regulation; allosteric enzymes, isozymes, co-enzymes and vitamins; immobilization and application of enzymes in industry. 2h
11. Growth and development: Phytochromes and light control, regulatory mechanism; role of phytochrome in phototropism; physiology of flowering and fruiting. 4h
12. Phytohormones: Auxin; cytokinin; Gibberellins; ethylene; ABA. polyamines; brassinosteroids jasmonate, their synthesis, distribution; and physiological effects. Molecular mechanism of action. Application of hormones in agriculture and horticulture. 5h
13. Signal Perception and Transduction - Overview, Plant receptors, G protein and phospholipids signaling, cyclic nucleotides, Role of Calcium in signaling, Protein kinases as primary elements in signaling, Particular pathways of signal transduction associated with plant growth regulators. 2h
14. Stress physiology: Abiotic and biotic stresses, morphological and cellular adaptation; molecular mechanism of stress tolerance and protection. 3h
15. Seed dormancy and germination, senescence, circadian rhythms in plants (exogenous factors and molecular mechanism). 2h
16. Secondary plant metabolities (steroids, alkaloids, tannins, phenols) in higher plants and lower organisms. General and specific biosynthetic pathways, Application, Allelopathic substances. 3h

PRACTICALS (any 15)

1. Verification of law of diffusion and osmosis
2. Determination of water potential and osmotic potential and RWC in plant tissue.
3. Analysis of plant tissue for
    (a) water, organic and inorganic content
    (b) determination of a few macronutrient by Flame photometer
    (c) and micronutrient by AAS.
4. Quantitative and qualitative estimation of sugars
5. Qualitative and quantitative determination of amino acids
6. Quantitative estimation of protein
7. Determination of ascorbic acid content of tissue.
8. Separation of protein by PAGE.
9. Pigments extraction, separation, identification and quantification.
10. Photooxidation of plant pigments
11. Determination of oxidative damage in tissue using TBARS method.
12. Enzyme activity with respect to temperature, pH and substrate concentration.
13. Effect of inorganic nutrients on plant growth (Hydroponic growth)
14. Isolation of intact organelles:
    (a) chloroplasts and
    (b) mitochondria.
15. Assay of photosynthetic electron transport activity from isolated chloroplast using oxygraph
16. Assay of respiratory electron transport activity from isolated mitochondria using oxygraph.
17. Non-invasive measurements of photosynthesis (chlorophyll fluorometer)
18. Assay of nitrate/nitrite reductase activity in leaves/algae.
19. Estimation of organic solute (proline) under stress condition.

BACK

BOC-301: PLANT MOLECULAR BIOLOGY **4 credits (3+1)**

1. Introduction to Molecular Genetics & Genomics – History of DNA molecule & discoveries since 1956 till date. Physical nature of DNA – DNA is the genetic material, Chemical nature of DNA, Structure of nucleotides, Bonding, double helix and other helices. Factors affecting DNA structure. How Genes function at Molecular level – Replication, Transcription & Translation. (6h)

2. Molecular Biology of DNA Replication –Enzymes involved in replication, DNA replication is semi-conservative, Meselson-Stahl expt., Multiple Origins & bi-directional DNA replication in Eukaryotes, Replication of Virus & Theta replication of Circular DNA molecules, Rolling Circle replication, Plasmid DNA using a Rolling Circle, Unwinding, Stabilization & Stress relief, initiation by a Primosome complex, Chain elongation & Proofreading, discontinuous replication of the lagging strand, Terminator sequencing of DNA. (8h)

3. Molecular Biology of Recombination - Molecular mechanisms of Recombination, Gene conversion, Mismatch repair, the Holliday model of recombination, Single strand break & repair model. (5h)

4.Transcriptions: Enzymes in transcriptions; Basic features of transcription, Initiation elongation and termination, promotors and enhancers; prokaryotic and eukaryotic transcription. (5h)

5.Regulation of Gene Expression – Regulation of gene expression in prokaryotes and Eucaryotes, Transcriptional Control I, expression of lac operon, Transcriptional Control II, Attenuation, Antitermination, Methylation, Yeast GAL regulatory pathway, alteration of gene expression by DNA sequence rearrangements in Salmonella, Trypanosoma & others. Transcriptional regulation in Eukaryotes (7h)

6. RNA Molecules & RNA Processing – Gene structure, Structure & Processing of messenger RNA, transfer RNA, ribosomal RNA, small interfering RNAs & micro RNAs, regulation through RNA processing & decay, alternative splicing, mRNA stability, co-suppression through RNA turnover, RNA interference (RNAi). (6h)

7. The Genetic Code & Translation – Molecular relation between Genotype & Phenotype, The Genetic Code, Factors involved in initiation, elongations and termination of translation, Post translational processing and modification, Transport of protein across the membrane (8h)

Practicals

1. Isolation and purification of genomic DNA from plant materials (3P)
2. Isolation and purification of RNA from plants (3P)
3. Quantitative estimation of genomic DNA and RNA using spectrophotometer (1P)
4. Agarose gel electrophoresis of genomic DNA and RNA and detection using gel documentation
5. system (1P)
6. ISSR random primers to amplify the genomic DNA of different plant materials using PCR and agarose gel electrophoresis of ISSR amplified genomic DNA and detection using gel documentation system and analysis of bands to understand genetic variation in plants (2P)
7. Analysis of gene sequence data bases of different plants species using WEB (2P)

Selected Reference Books

1. James D. Watson, Tania A. Baker, Stephen P. Bell, Alexander Gann, Michael Levine and Richard Losick. 2008. Molecular Biology of Gene. Sixth Edition. Cold Spring Harbor Laboratory Press, Cold Spring Harbor, New York.U.S.A.
2. Primrose, S. B. and R. M. Twyman. Principles of Gene Manipulation and Genomics. 2009. Seventh Edition. Blackwell Publishing, U.S.A.
3. Brown T. A. 2007. Genomes. Third Edition. Garland Science Publishing, New York. U.S.A.
4. Benjamin Lewin. 2008. GENES IX. Jones and Bartlett Publishers, London, UK.
5. Mary A. Schuler and Raymond E. Zielinski. 2005. Methods in Plant Molecular Biology. Academic Press, USA.
6. R. J. Henry. 2005. Practical Applications of Plant Molecular Biology. Chapman & Hall, London, UK.
7. David Freifelder. 1990. Molecular Biology. Second Edition. Narosa Publishing House, New Delhi.
8. Shaw, C. H. 1988. Plant Molecular Biology, Practical Approach. IRL Press, Oxford, Washington DC.
9. Grierson D and S. Covey. 1984. Plant Molecular Biology. Panima Educational Agency, New Delhi.
10. Gloria Coruzzi 1994. Plant Molecular Biology - Genetic Analysis of Plant Development and Metabolism. Springer-Verlag, New York, London.
11. Tewari, K. K. and G. S. Singhal.1997. Plant Molecular Biology and Biotechnology. Narosa Publishing House, New Delhi.

BACK

BOC-302: PLANT GENETIC ENGINEERING. 4 credits (3+1)

1. Restriction and modification of DNA: Basic principle of genetic engineering; restriction enzyme, cutting and joining the DNA; Vectors: plasmids, fine structure of vector gene desirability traits; construction of plasmid, purification of plasmids, various types of plasmids, Bacteriophage and cosmid, single and double standard vectors; various cloning strategies, Genome library and cDNA library, selection strategies for desired transformants, Genetic system provided by E.Coli and its host. 9h
2. Agrobacterium-mediated gene transfer- Biology and molecular basis of Agrobacterium mediated plant transformation and its application. Direct gene transfer methods, Plant Breeding vs Genetic Engineering. 6h
3. Site directed mutagenesis: DNA sequencing, various strategies for carrying out site directed mutagenesis, Generation of Mutants in plants-TDNA and transposon-based gene knockouts, chemical mutagenesis, DNA polymorphic markers, RFLP, ISSR, 6h
4. Structure and expression of plant genome; general organisation of nuclear, mitochondrial and chloroplast genome; structure and organisation of histone genes, Genetic interactions in nucleus, chloroplast and mitochondria; Genetic codes in organelles; Genetics of biogenesis and functioning of chloroplast and mitochondria, retrograde signalling 9h,
5. Gene silencing in plants - Post transcriptional and transcriptional gene silencing, mutants of gene silencing, RNA virus in plants, virus induced gene silencing and its application. RNAi, Antisense. 6h
6. Application of plant genetic engineering: Genetic engineering of plants for herbicide resistance, insect resistance, virus and abiotic stress resistance; targeting of protein to chlorophyll and mitochondria; Improvement of crop yield and quality - Role of Ethylene in fruit ripening, Mutants in fruit ripening, Genetic manipulation of fruit ripening, Molecular pharming & Plantibodies, Reversible male sterility in plants, Antisense RNA; rice genome project, other sequenced genomes, Golden rice. 6h
7. Genetic Engineering and public Concerns – Ethical & Environmental concerns on Genetic Engineering of plants. Genetically Engineered Foods, Safety of Genetically Engineered Foods, Labeling, Future Foods and Regulatory Challenges, 'Pharm' Factories of the Future. 2h
8. Field testing of transgenic plants; Bio-safety issues in Indian contest; Indian rules, regulation and procedures for handling transgenic plants. 1h

Practicals: **(Any 15)**

1. Culture of plasmid and maintaining of a culture 2
2. Purification of 3
   (a) plasmid and cyanobacteria/algae
   (b) plant DNA
   (c) Plant RNA
3. Quantitative and qualitative determination of DNA preparation. 1
4. Agarose gel electrophoresis and gel analysis using gel document system. 2
5. Digestions of DNA by restriction enzymes and size fractionation of fragments 1
6. Ligation of digested fragments. 1
7. RNA isolation from plasmid/cyanobacteria/algae, quantification and running of natured and denatured gel 2-3
8. cDNA formation using reverse transcriptase. 1
9. PCR cycle for amplification of the isolated cDNA. 1-2

10.	Semi-quantitative analysis of one of the gene (SOD)	1
11.	RT-PCR quantitation of selected gene(s) using SYBRG	2
12.	Use of software for quantitation of gene and compare the expression level	2
13.	Primer designing	2
14.	Southern Blotting	1
15.	Northern Bloting	1
16.	Western Blotting	1
17.	Creating a transformant using commercial construct	2
18.	16 or 18s rRNA analysis	2

Leaf disc transformation using agrobacterium, establishment of transgenic plants and GUS staining of GFP viewing. 3

BACK

BOC - 401: CYTOGENETICS AND PLANT BREEDING **4 credits (3+1)**

1. Cell division and Cell cycle: In prokaryotes and Eukaryotes; Eukaryotic chromosome replication; Regulation of Mitotic Phase (M Phase); Mitosis and Meiosis, their significance; Bacterial genome; Viral genome. (5L)
2. Morphology of eukaryotic chromosomes: Chromosome number, size and general morphology; Karyotype; Chromosomes banding patterns; Specialized chromosomes; B chromosomes; Adaptational forms and normal chromosomes; Chromosome movement; Prokaryotic nucleoids; Fluorochromes. (5L)
3. Molecular organization of Eukaryotic chromosomes: Chemical composition, chromosome structure; Organization of chromatin fibres; Molecular structure of Centromere and telomere. (3L)
4. Organellar chromosomes: Basis of extra nuclear inheritance; Plastid inheritance, Mitochondrial inheritance; Organellar DNA – Chloroplast DNA (cpDNA), Mitochondrial DNA (mtDNA), Replication of cpDNA and mtDNA. Promiscuous DNA, Origin of mitochondria and chloroplast. (4L)
5. Plasmids, IS elements, transposons and Retroelements: plasmids, Insertion sequence or IS elements; Transposons and controlling elements (in prokaryotes and Eukaryotes - copia, FB, P and I in Drosophila; Ty in yeast; Tam 1 in snapdragon dotted, AC-DC and Spm in corn; Retroelement (viral and non viral); Mechanism of transposition, uses of transposons. Evolutionary significance. (5L)
6. Molecular mechanisms to mutation and DNA repair – Types of mutations; Molecular basis of mutations; spontaneous mutations, reverse mutations and suppressor mutations; mutagens, mechanism of DNA repair. (4L)
7. Introduction to Plant Breeding: Objectives and achievements; Pattern of evolution in crop plants; Plant introduction - Purpose of plant introduction; some important achievements of plant introduction; Domestication and acclimatization; Germplasm collections. (5L)
8. Heterosis and inbreeding depression: Inbreeding depression; Effects of inbreeding; Degrees of inbreeding depression; Homozygous and Heterozygous balance; Heterosis in cross and self-pollinated plants; Genetic basis of heterosis and inbreeding depression; Dominance hypothesis; Over-dominance hypothesis; Physiological basis of heterosis; Commercial applications.(6L)
9. Distance hybridization and in-vitro techniques in plant breeding: Barriers to production of distant hybrids; interspecific and intergeneric hybridization and their application in crop improvement; embryo culture, Meristem culture, anther and pollen culture, achievements and future prospects; release of new varieties. (4L)
10. Genetics and crossing techniques of economically important crop plants - Wheat, Rice, Maize and Cotton. (4L)

PRACTICALS: (Any 15)

1. Mitotic studies in suitable material. Squashing of the root tip and selection of metaphase plate.
2. Mitotic studies in suitable material*:* Camera lucida drawing, Karyotype analysis, Dendrogram and derivation of karyotypic formula.
3. Preparation of metaphase plate and chromosome count in *Urginea indica.*
4. Meiosis in *Allium cepa.*
5. Meiosis in translocation heterozygotes – *Rheo* sp.
6. Observation of B chromosomes in suitable material – *Zea mays.*
7. Centre of origin of some economically important crop plants.

8. Effect of chemical mutagen (DES/HZ/EMS) on germination, growth and yield characteristics *Brassica sp.*
9. Effect of chemical mutagen (DES/HZ/EMS) on germination, growth and yield characteristics *Impatiens balsamina*
10. Floral biology of Oryza sativa.
11. Crossing techniques in *Oryza sativa.*
12. Floral biology of Zea mays.
13. Crossing techniques in *Zea mays.*
14. *In vitro* study of anther culture technique using suitable material.
15. Induction of polyploidy using Colchicin.
16. Studies in *Drosophila*: Preparation of culture media and Study of different stages in the life cycle of *Drosophila*.
17. Studies in *Drosophila*: Study of Salivary gland chromosomes.

REFERENCE BOOKS

1. Ahluwalia K.B. (1985). Genetics. Wiley Eastern Ltd.
2. Berns M.W. (1986) Cells. Saunders College Publishing.
3. Burns G.W. and Bottino P.J. (1983). The Science of Genetics. Maxwell McMillan International.
4. Chaudhari H.K. (1984). Elementary principles of plant breeding. Oxford and IBH Publishing Company.
5. Dyansagar V.R. (1986). Cytology & Genetics. Tata McGraw- Hill Publishing Co.
6. Doods J.H. (1985) Plant Genetic Engineering. Cambridge University Press.
7. Poehlman J.M. and Borthakur D. (1969), Breeding Asian field crops. Oxford and IBM Pub. Company.
8. Sharma A. (1990). Chromosomes. Oxford and IBH Publishing Company.
9. Singh B.D. (1986). Plant Breeding. Kalyani Publishers.
10. Swanson C.P. Merz T. and Young W.J. (1990). Cytogenetics. Prentice Hall of India.
11. Swanson C.P. and Webster P.L. (1989). The Cell. Prentice Hall of India.
12. Sinha, U. and Sinha U. (1976) Cytogenetics, Plant Breeding and Evolution. Vikas Publishing House Pvt. Ltd.
13. Ganguly, A.K. and Kumar, N.C. (1991) an Introduction to cytology Genetics; Evolution and Plant Breeding. Em Kay Publications.
14. Chopra, V.L. (1989). Plant Breeding. Oxford Publications.

BACK

OPTIONAL COURSES

BOO-101: TECHNIQUES AND INSTRUMENTATION IN BOTANY. 4 credits (3+1)

1. Laboratory practices and safety in laboratory: General safety measure, Chemical hazards, Physical hazards, Biological hazards, spillage and waste disposal, disposal of radioactive waste, first aid. 3h
2. pH and buffer solutions: SI units; Molarity and moles; Acids and base; Hydrogen ion concentration and pH, Dissociation of acids and bases; Buffer solutions. 3h
3. Chromatography Techniques: General Principles and techniques, principle, application and material of column chromatography; Thin layer chromatography; Paper chromatography; Adsorption chromatography; Partition chromatography; (liquid-liquid chromatography); Gas-liquid chromatography; Ion exchange chromatography; Exclusion chromatography; Affinity chromatography; High performance liquid chromatography. 12h
4. Electrophoresis Techniques: General principles; Principle, material and application of Isoelectric focusing, SDS - PAGE (sodium dodecyl sulphate); Isotachophoresis; Low and high voltage electrophoresis; Preparative Electrophoresis; Detection, recovery and estimation. 9h
5. Spectroscopic Techniques; General principles; Radiation energy and atomic structure; Basic law of light absorption; Types of spectra and their biological usefulness. Principle, application and instrumentation of UV-VIS spectrophotometry; IR (infra-red) spectrophotometry; CD (circular dichoresim) spectrophotometry; Spectrofluorometry; Luminometry; Atomic/flame spectrophotometry; Mass spectrometry; ESR (electron spin resonance) and NMR (nuclear spin resonance). 12h
6. Radiobiology: The nature of radioactivity; Atomic structure, stability and radiation; Isotopes; Types of radioactive decay; Detection and measurement of radioactivity; Geigermuller counter; Scintillation counter; Applications of radioisotopes in biological sciences; Safety aspects of use of radioisotopes. 3h
7. Centrifugation Techniques: Basic principles of sedimentation; Centrifuge and their use; Small bench centrifuge; High speed refrigerated centrifuge; Continues flow centrifuge; Preparative ultracentrifuges; Analytical ultracentrifuges; Density gradient centrifugation; Preparative centrifugation; Design and care of rotors, safety aspects in the use of centrifuges. 3h

Practicals: (15)

- Preparation of molar and other solution and setting of pH
- Absorption spectra of various compounds to understand λ max, substance absorption
- Verification of Beer's law
- pKa value of a buffer/ amino acids using pH meter
- IEF* (learning of gel formation and role of various components)
- SDS-PAGE of membrane proteins* (learning of gel formation etc.)
- Drying and analysis of gel
- Separation of organelles based on density gradient centrifugation (Using percoll or sugar gradient)
- TLC for separating and identifying biomolecules
- GC*; HPLC*
- Fluorescence spectrophotmetry
- Flame photometry; Atomic absorption spectrophotometry*
- Scintillation counter*
- Centrifuges and rotor heads

*INDICATE ACTUAL DEMOSTRATION ONLY. BACK

BOO-102: Bioinformatics and Chemoinformatics **4 credits**

Module I **(15h)**

1. Introduction to Bioinformatics , Nature of biological data, Overview of available Bioinformatics resources on the web, NCBI/EBI/EXPASY etc (3)
2 Biological Databases: Nucleic acid sequence databases, GenBank/EMBL/DDBJ Protein sequence databases, SwissProt, UniProtKB, Genome databases-OMIM, structural databases, PDB, NDB, CCSD, drived databases Prosite, BLOCKS, Pfam/Prodom, Dat abase search engines, Entrez , SRS (3)
3. Overview/concepts in sequence analysis, Pairwise sequence alignment algorithms, Scoring matrices for Nucleic acids and proteins ,Database Similarity Searches –BLAST, FASTA Multiple sequence alignment, PRAS, CLUSTALW (3)
4. DNA and Protein Microarrays (1)
5. Macromolecular Structure and Overview of molecular modeling Protein - Primary, Secondary, Supersecondary, Tertiary and Quaternary structure, Nucleic acid – DNA and RNA, Carbohydrates, 3D Viral structures, Methods to study 3D structure, Analysis of 3D structures (2)
6. Principles of protein folding and methods to study protein folding (1)
7. Maromolecular interactions , Protein – Protein, Protein – Nucleic acids , Protein – carbohydrates (1)
8. Introduction to Molecular modelling methods (1)

Module II

Chemoinformatics **(15 h)**

1. Role of Chemoinformatics in pharmaceutical/chemical research, Integrated databases, HTS analysis, Ligand based design of compounds, Structure based design of compounds (2)
2. Overview of Structure representation systems, 2D and 3D structures, General introduction to chemical structure-hybridization, tetrahedron geometry etc, The degeneracy of isomeric SMILES and introduction to unique SMILES, Internal co-ordinates and introduction to calculation of Z matrix of simple small organic molecules. (2)
3. Chemical Databases – Design, Storage and Retrieval methods (1)
4. Introduction to database filters, property based & (drug-like)-Lipinski Rule of Five (1)
5. Search techniques, similarity searches and clustering (1)
6. Modeling of small molecules and methods for interaction mapping (1)
7. Characterization of chemicals by Class & by Pharmacophore, application in HTS Analysis (1)
8. Introduction to pharmocophore, Identification of pharmacophore features, Building pharmacophore hypothesis, Searching databases using pharmacophores (2)
9. Overview of Quantitative Structure Activity Relationship & application to Hit to lead optimization (1)
10. Chemoinformatics tools for drug discovery-Integration of active drugs ,Optimization techniques , Filtering chemicals, In silico ADMET; QSAR approach, Knowledge-based approach (3)

Practicals:

Bioinformatics (15)

1. Exploring NCBI database system, querying the PUBMED and GenBank databases , EBI server and searching the EMBL Nucleotide database, Exploring & querying SWISSPROT & UniProtKB (2)
2. Pair-wise global alignments of protein and DNA sequences using Needleman-Wunsch algorithm & interpretation of results to deduce homology between the sequences, use of scoring matrices, Pair-wise local alignments of protein and DNA sequences using Smith-Waterman algorithm and interpretation of results (2)
3. Database (homology) searches using different versions of BLAST and FASTA and interpretation of the results to derive the biologically significant relationships of the query sequences (proteins/DNA) with the database sequences (3)
4. Multiple sequence alignments of sets of sequences using web-based and stand-alone version of CLUSTAL. Interpretation of results to identify conserved and variable regions and correlate them with physico-chemical & structural properties (2)
5. Exploring and using the derived databases: PROSITE, PRINTS, BLOCKS, Pfam and Prodom for pattern searching, domain searches etc. (1)
6. Search & retrieval: genomic and OMIM data at NCBI server, Exploring the Database & searches on PDB and CSD, WHATIF, Interpreting DNA and Protein microarray data (1)
7. Studying the format & content of structural databases, Molecular visualization tools :- Visualization of tertiary structures, quaternary structures, architectures and topologies of proteins and DNA using molecular visualization softwares such as RasMol, Cn3D, SPDBV, Chime, Mol4D, etc. (2)
8. Structure prediction tools and homology modeling, Comparison of the performance of the different methods for various classes of proteins, Prediction of tertiary structures of proteins using Homology Modeling approach: SWISSMODEL, SWISS-PDB Viewer (2)

Practicals

Chemoinformatics (15)

1. Introduction to basic chemoinformatics software/tools-ACDsketch, Chemsketch, Jchem VegaZZ etc. NCL's moltable , Chembiofinder (3)
2. Importance of storing chemical in the form of graph, linear notation (SMILES,WLN, ROSDAL-with special emphasis on SMILES and stereochemistry- both optical and geometrical isomerism), connection tables-sd and mol files. (2)
3. Importance of 3D structure and methods available for 3D structure generation- CORINA and CONCORD (2)
4. A brief introduction to database (ISIS Base) with special emphasis on the storage of chemical in the database format. (2)
5. Substructure searching and general property calculation-rotatable bonds, hydrogen bond donor, hydrogen bond acceptor, molecular weight, molecular refractivity, molecular volume, surface area and polar surface area. (3)
6. Representing SMARTS, Recursive and Component level SMARTS and linear representation of chemical concepts like Pka, pH, Zwitterions, Functional Groups, Aromaticity (2)
7. Molecular docking-Drug docking basics (1)

Reference and Text books:

Bioinformatics

- Bioinformatics: A Practical Guide to the analysis of Genes and Proteins (2nd Ed.) by Baxevanis, A.D. & Ouellettee, B., F. F., New York, John Wiley & Sons, Inc. Publications, 2002.
- Introduction to Bioinformatics by Attwood, T.K. & Parry-Smith, D.J., Delhi, Pearson Education (Singapore) Pte.Ltd., 2001.
- Bioinformatics: Sequence and Genome Analysis by Mount, David, New York, Cold Spring Harbor Laboratory Press, 2004.
- Current Protocols in Bioinformatics by Baxevanis, A.D., Davison, D.B., Page, R. D. M. & Petsko, G.A., New York, John Wiley & Sons Inc., 2004.
- Structural Bioinformatics - Methods of biochemical Analysis V. 44 by Philip E. Bourne (Editor), Helge Weissig (Editor) New Jersey. Wiley-Liss, 2003.
- Principles of protein X-ray Crystallography by Jan Drenth, Springer-Verlag, 1994.
- Introduction to Protein Structure by Branden, Carl & Tooze, John, Garland Publishing, 1991.
- Molecular Modeling: Principles and Applications by Andrew Leach, Prentice Hall, 2001.
- Computational methods for protein folding : advances in chemical physics vol. 120 by Friesner, R.A. Ed., Prigogine, L. Ed. & Rice, S.A.New York. John wiley & sons, Inc. publication, 2002.
- Dynamics of Proteins and Nucleic Acids by J.A. McCammon and S.C. Harvey Cambridge University Press, 1087.
- Protein Structure: A Practical approach by Creighton T. E., 1989.
- Protein Folding by Creighton T., 1992.
- Protein Structure Prediction: A practical approach by Sternberg M.J.E., 1996.
- Molecular Modeling: Basic Principles and application by Hans Dieter and Didier Rognan. Wiley VeH Gmbh and Co. KGA, 2003.
- Prediction of protein structure and the principles of protein conformation by Fasman, G.D. New York. Plenum Press, 1989.
- Protein modules in cellular signaling edited by Heilmeyer, L. & Friedrich, P. Amsterdam . IOS Press, 2001.
- Metal sites in proteins and models by Hill, H.A.O., Sadler, P.J. & Thomson, A.J Berlin. Springer, 1999.
- Protein structure prediction: methods and protocols by Webster, D. M., Ed. Totowa Humana Press, 2000.
- Modular protein domains by Gimona, G. Cesareni. & Yaffe, M. Sudol (EDS.), USA., Wiley-vch verlag gmbh & co.,3-527-30813-X , Aug. 2004.
- Molecular modeling: basic principles and applications by Holtje, H.D. & Folkers, G., Weinheim, VCH, 1997.
- Molecular Modeling: Basic Principles and application by Hans Dieter & Didier Rognan, Wiley VeH Gmbh and Co. KGA, 2003.
- Arthur M. Lesk (2003) Introduction to Bioinformatics, Oxford University Press, Indian edition
- Des Higgins and Willie Taylor (2000). Bioinformatics, Sequence, structure and databanks. A practical approach. Oxford University Press, Indian edition, Second impression, New Delhi

- Imtiaz Alam Khan (2005). Elementary bioinformatics. Pharma Book Syndicate, Hyderabad
- Irfan Ali Khan and Attiya Khanum (eds.) (2002). Emerging trends in Bioinformatics. Ukaaz Publications, Hyderabad
- Irfan Ali Khan and Attiya Khanum (eds.) (2005). Basic concepts of Bioinformatics, Ukaaz Publications, Hyderabad
- Irfan Ali Khan and Attiya Khanum (eds.) (2004). Introductory Bioinformatics. Ukaaz Publications, Hyderabad
- Krane Dan, E. and Raymer M.L. (2004). Fundamental concepts of Bioinformatics. Pearson education. New Delhi. Second Indian reprint.
- Rastogi, S.C., Mediratta, N., Rastogi. P. (2004), Bioinformatics, methods and applications, genomics, proteomics and drug discovery, Prentice hall of India, pvt. Ltd., New Delhi
- Stephen Misener and Stephen Krawetz (eds.) (2004) Bioinformatics, methods and protocols, methods in molecular biology, Volume 132, Humana Press, New Jersey, Third Indian reprint
- T K Atwood and D J Parry-Smith (2004) Introduction to Bioinformatics, Pearson education, New Delhi
- Xiong, Jin (2006) Essential bioinformatics, Cambridge university press

- **Chemoinformatics**

- Chemoinformatics: Theory, Practice & Products (2009) Barry A. Bunin , Brian Siesel, Guillermo Morales Jürgen Bajorath, Springer
- Pharmaceutical Data Mining: Approaches and Applications for Drug Discovery (2009) Konstantin V. Balakin Sean Ekins (Series Editor) , Wiley
- Chemoinformatics: An Approach to Virtual Screening (2008), Alexandre Varnek Alexander Tropsha (Editor) , Royal Society of Chemistry
- Chemoinformatics: Concepts, Methods, and Tools for Drug Discovery (Methods in Molecular Biology), (2004) J. bajorath (ed.) Humana Press
- Chemoinformatics (2004) Johann Gasteiger and Thomas Engel.
- An introduction to Chemoinformatics (2003) Andrew R. Leach and Valerie J. Gillet, Kluwer Academic Publisher,
- Handbook of Chemoinformatics. From Data to Knowledge 92003). Johann Gasteiger.
- Chemometrics and Chemoinformatics (2005) Barry K. Lavine, ACS Symposium series 894.
- Molecular modelling and prediction of bioactivity (2000) by Gundertofte, K. & Jorgensen, F.S. New York. Kluwer academic publishers.

- **Addresses of public domain database/tools/resources/ free ware websites**

- DBGET-http://www.genome.jp/dbget/
- LinkDB-http://www.genome.jp/dbget/linkdb.html
- Fgenes-http://www.softberry.com/berry.phtml?topic=products
- GeneBuilder-http://www.itb.cnr.it/sun/webgene/
- GeneSCAN-http://genes.mit.edu/GENSCAN.html
- GRAIL-http://compbio.ornl.gov/Grail-1.3/
- CLC Free Workbench http://www.clcbio.com/index.php?id=28
- BioEditor-http://bioeditor.sdsc.edu/
- CN3D 4.1 -http://www.ncbi.nlm.nih.gov/Structure/CN3D/cn3d.shtml

- Protein-Explorer-http://www.umass.edu/microbio/chime/pe_beta/pe/protexpl/frntdoor.htm
- Chimera-http://www.cgl.ucsf.edu/chimera/
- Yasara-http://www.yasara.comhttp://www.yasara.com)
- Ribosome builder-http://rbuilder.sourceforge.net/
- ArrayExpress-www.ebi.ac.uk/arrayexpress/
- EPICLUST-http://ep.ebi.ac.uk/EP/
- RasMOL-http://www.umass.edu/microbio/rasmol/
- 17.CHIME-www.mdl.com/chime/

BACK

BOO-103: Enology - Principles and practice of winemaking (1 credit Theory)

1. Overview of Enology, contrast between ancient and modern methods of wine making (1L)
2. Viticulture and Grape Species (1L)
3. Wine Types and Styles, Wine Regions and Terroir, the Indian wine scene (with emphasis on Goa)(2L)
4. Harvesting and Processing of grapes and other fruits (1L)
5. Sources of contamination in wine making, Sanitation and Sterilization (1L)
6. Scales of winemaking, microvinification, Materials and supplies used in wine making (2L)
7. Chemistry and cell biology of fermentations with yeast and bacteria (2L)
8. Fermentation Processes, Post-Fermentation (1L)
9. Wine Analysis, Chemical Components of Wine, Biochemical Reactions in Fermentation (1L)
10. Wine Acids, Aroma compounds (Terpenes), Color and Flavor Compounds (phenolics, Tannins) (1L)
11. Sensory evaluation and Quality control in wine making 1L/demo
12. Wine bottling, corking, packaging and marketing 1 L/demo

For demos visit to be organised to local wineries:-
Le Meredien Distillry & Winery, Vinicola, Margao

Recommended books

1. Amerine, M. A., Berg, H. W., Kunkee, R. E., Ough, C. S., Singleton, V. L., Webb, A. D. 1980. *The Technology of Winemaking*. 4th edition. AVI Publishing Co. Inc. Westport.
2. Amerine, M. A., Roessler, E. B. 1983. *Wines: Their sensory evaluation*. WH Freeman & Co. San Francisco.
3. Amerine, M. A., Singleton, V. L. 1977. *Wine: An Introduction to the Wines of the World, Grape Cultivation, Techniques of Wine-making, and How to Evaluate and Enjoy Wines*. University of California Press.
4. Boulton, R. B., Singleton, V. L., Bisson, L. F., Kunkee, R. E. 1996. *Principles and Practices of Winemaking*. Chapman and Hall, New York.
5. Fleet, G. H. 1993. *Wine Microbiology and Biotechnology*. Harwood Academic Publishers, Chur.
6. Fugelsang, K. C. 1997. *Wine Microbiology*. Chapman & Hall, New York.
7. Iland, P, Ewart, A, Sitters, J. 1993. *Techniques For Chemical Analysis and Stability Tests Of Grape Juice and Wine.* Patrick Iland Wine Promotions, PO Box 131, Campbelltown, South Australia 5074.
8. Iland, P. 1991. *An Introduction to Wine: A Guide to the Making, Tasting, and Appreciation of Wine*. Patrick Iland Wine Promotions, PO Box 131, Campbelltown, South Australia 5074.
9. Jackson, R. S. 2000. *Wine Science: Principles, Practice, Perception.* Second Edition. Academic Press, Inc., 525 B Street, Suite 1900, San Deigo, California.
10. Linskens, H. F., Jackson, J. F. 1988. *Wine Analysis: Modern Methods of Plant Analysis.* New series volume 6. Springer Verlag.
11. Ough, C. S. 1991. *Winemaking Basics.* Food Products Press, New York.
12. Ough, C. S. and Amerine, M. A. 1988. *Methods For Analysis of Musts and Wines*. Second Edition. J. Wiley & Sons, New York.
13. Ribereau-Gayon, P., D. Dubourdieu, and B. Doneche, A. Lonvaud (eds.). 2000. *Handbook of Enology Volume 1: Microbiology of Wine and Vinifications.* John Wiley & Sons, New York.

14. Ribereau-Gayon, P., Y. Glories, A. Maugean, and D. Dubourdieu. (eds.). 2000. *Handbook of Enology Volume 2: Microbiology of Wine, The Chemistry of Wine Stabilization and Treatments.* John Wiley & Sons, New York.
15. Robinson, J. (ed.). 1994. *The Oxford Companion to Wine*. Oxford University Press, Oxford, New York.
16. Schahinger, G., Rankine, B. 1992. *Cooperage for Winemakers: A manual on the construction, maintenance, and use of oak barrels.* Ryan Publications, Adelaide, South Australia.
17. Storm, D. R. 1997. *Winery utilities: planning, design and operation.* Chapman & Hall, New York.
18. Vine, R. P. 1981. *Commercial Winemaking, Processing and Controls*. AVI Publishing Co., Westport, CT.
19. Vine, R. P. (ed.), E. M. Harkness, T. Browning, C. Wagner, and B. Bordelon. 1997. *Winemaking: from grape growing to marketplace.* Chapman & Hall, New York.
20. Waterhouse, A. L. and S. E. Ebeler (eds.). 1998. *Chemistry of Wine Flavor.* American Chemical Society, Washington, D.C.
21. Zoecklein, B. W., Fugelsang, K. C., Gump, B. H., Nury, F. S. 1990. *Production Wine Analysis*. An AVI book.
22. Zoecklein, B. W., Fugelsang, K. C., Gump, B. H., Nury, F. S. 1995. *Wine Analysis and Production*. Chapmann & Hall, New York, NY.

Enological websites

1. Academic study of winemaking from the University of California, Davis
http://www.wineserver.ucdavis.edu

2. web site for american journal of enology and viticulture.
http://www.ajevonline.org

3. Internet journal of viticulture and enology
infowine
http://www. infowine.com

BACK

BOO-104: MINE WASTELAND MANAGEMENT **(1 Credit Theory)**

1. Definition of the terms: Rehabilitation, Remediation, Reclamation, Restoration and Ecorestoration; Concept of Sustainable and unsustainable development. (1L)

2. Type of mining: Open cast and underground; Mineral resources - use (including economic impacts) and exploitation; Flora of mine wastelands (natural and managed). (2L)

3. Environmental issues: Problems (man induced landslides, soil erosion, land degradation, pollution of water bodies and agricultural fields, air pollution and health risks); Case studies. (3L)

4. Mine wasteland reclamation strategies: Physical, Chemical and Biological; Revegetation and revegetation plan; silvicultural characteristics and selection of plant species (indigenous v/s exotic); Management through social forestry, Psiculture. (3L)

5. Nursery techniques: Seed and clonal viability, Quality and storage; Seed dormancy and methods to overcome seed dormancy; Natural and artificial regeneration; Raising nurseries; Planting methods in the field; Agronomic practices; Post planting care; monitoring indicators. (3L)

6. Microbial Management, EIA and Reclamation Act: Microbial management and biofertilizers for restoring soil fertility; Low cost input approach for revegetation of iron ore mine spoil – A case study; Environmental Impact assessment; Surface mining control and Reclamation Act. (3L)

BACK

BOO-105: Practical course in plant identification (1 credit) practical

1. Exposure to morphological terms using locally available specimens. (1)
2. Use of dichotomous keys for identification. (1)
3. Use of electronic keys for identification. (1)
4. Field characters in family identification (by conducting actual field studies – one in each month for three months to cover maximum families). (3)
5. Preparation of herbarium specimen and working out herbarium specimen under microscope. (2)
6. Scientific illustration (line drawing) following basic rules for proportion, scientific accuracy, scale, numbering and legend. (1)
7. Identification of locally available specimens to species level using Floras (to be covered in six practical classes). (6)

(Journal, record & preparation to be assessed for ISA)

BACK

BOO-201: PLANT ANIMAL INTERACTION (3 credits)

Diversity of Plant-Animal interactions: Mutualism, Antagonism, Commensalism, Competetion, Multi-trophic level interactions; Species interactions and the evolution of biodiversity; Co-evolution and co-speciation of plants and animals; adaptive radiation; evolutionary history of interactions and evidences in the geological past; principle of allocation. (5)

Pollination Biology: Importance of cross pollination. Evolutionary origin and early diversification of animal pollination; Special differentiation associated with pollinator attraction - advertisement and reward (pollen. Nectar, elaiophores, resin glands, osmophores, optical displays and visual clues). Floral adaptation to different pollinators; insect visitors (Hymenoptera, Diptera, Coleoptera, Lepidoptera, Thysanoptera), birds, bats, non-flying animals. Sapromyiophily, brood-site pollination; fig-wasp interaction and pollination. Pollination biology and gene flow: foraging theory, foraging strategies and time-niche strategies. (7)

Fruits, Seeds and Dispersal agents; Plant adaptations - Fruit chemistry (chemical compartmentalization - pulp and seed, nutritional aspect of pulp, palatability inhibitors and toxins). Seed coat, seed toxins. Phenology; signals, fruit size and fruit production. Dispersers: range of seed dispersers, frugivores as foragers. Animal adaptations – External and internal morphology, digestive physiology, behavious. Factors limiting reciprocal, plant and animal specializations. Seed shadow; seed predators. (5)

Herbivores and green plants: Nutrional requirements of insects, seasonal and temporal distribution of nutrients in plant parts; Co-evolutionary arms race - plant defence and animal response; plant defences against herbivores – physical, chemical and 'third party' defences; animal responses – behavious, detoxification, conjugation, target-site insensitivity, excretion. Herbivory vs plant fitness. Herbivore efficiency and ecosystem dynamics, effect of herbivores on plant communities – The Janzen-Connell hypothesis Effect of herbivores on plant communities. (8)

Ant-plant interactions: The origin and early evolution; the varieties of ant-plant symbioses - Mutualism and non-mutualism (herbivores, harvesting ants, granivores and leaf-cutting). Ants as primary and secondary seed dispersers; pollination by ants; direct and indirect association with plants; ant-fed plants and ant gardens; canopy ants; effects of harvesters on vegetation. Temporal and spatial variations in ant-plant interactions Fungus growers. (5)

Carnivorous plants: Mechanisms of interaction between carnivorous plants and animals, trap mechanisms; nutritional benefits of carnivory, cost-benefit analysis. Evolutionary pathways to carnivory.

(4)

Hormonal interaction between plants and animals; hormone signaling in trophic interactions; animal pheromones and defence substances. (4)

Plant communities as animal habitats: Adaptations, ecological segregation within and between habitats; mechanisms of habitat selection, habitat selection theory, characterestics of plant resources and animal population dynamics, effects of plants on animal spacing and aggression. Animal diversity in relation to plant resource characteristics. (4)

Plant-animal interactions in agricultural ecosystems; future directions. (3)

Recommended books:

Abrahamson, W.G. (ed.), 1989. Plant-animal interactions. McGraw-Hill Book Company, NY.

Crawley, M.J. 1986. Plant Ecology. Blackwell Scientific Publications.

Endress,P.K.1994.Diversityand Evolutionary biology of tropical flowers. Cambridge University Press.

Harborne, J.B. 1988. Introduction to ecological biochemistry. Academic press.

Holldobler, B. & Wilson, E.O. 1990. The Ants. Springer-Verlag.

Lloyd, D.G. & Barret, S.C.H., 1996. Floral Biology: studies on Floral evolution in Animal pollinated plants. Chapman & Hall.

Proctor, M., Yeo, P. & Lack, A. 1996. The Natural History of Pollination. Harper Collins Publishers.

Richards, A.J. 1986. Plant Breeding systems. George Allen & Unwin, London.

Smith, R.L. 1990. Ecology and field biology. Harper Collins publishers.

Van der Pijl, L. 1969. Principles of dispersal in Higher plants. Springer-Verlag.

Whitmore, T.C. 1990. An introduction to tropical rain forests. Clarendon Press, Oxford.

BACK

BOO-202: ETHNOBOTANY (2 credit theory)

Ethnobotany: Introduction; a brief history of ethnobotanical studies in the world and in India; scope of ethnobotany. Subdisciplines of ethnobotany. Interdisciplinary approaches. Knowledge of sociological and anthropological terms. (5 L)

Distribution of tribes in India. Knowledge of tribes of Konkan, Goa and Kanara; Ethnobotanical works on these tribes. (5 L)

Sources of ethnobotanical data: Primary - archeological sources and inventories, Secondary - travelogues, folklore and literary sources, herbaria, medicinal texts and official records. Methods in ethnobotanical research. Research design and cautions in data collections, Practical and field skills; Prior Informed Consent, PRA techniques, interviews and questionnaire methods, choice of resource persons. (5 L)

Ethnobotanical knowledge and communities: Ethnobotanical classification; Folk Taxonomy of Plants. Non timber Forest Produce (NTFP) and livelihood. Sustainable harvest & value addition. Ethnomycology. Conservation and Community Development. (5 L)

Bioprospecting and commercial use of traditional knowledge. Medical ethnobotany, ethnopharmacology and the search of plant based drugs. Developing research partnerships: Ethics and research guidelines in ethnobotany, equitable research relationships. (5 L)

Traditional knowledge (TK) in relation to Intellectual Property Rights and Biopiracy. Equitable Benefit sharing models of the world. (5 L)

Suggested Reading

Alexiades, M., ed. 1996. *Selected guidelines for ethnobotanical research: A field manual*. New York: New York Botanical Garden.

Apte, T. 2006. Intellectual Property Rights, Biodiversity and Traditional Knowledge. Kalpavriksh, Grain & IIED, Pune / New Delhi.

Begossi, A. 1996. Use of ecological methods in ethnobotany. *Economic Botany* 50 (3): 280–89.

Balee W. L. 2003. Footprints of the Forests. Bishen Singh Mahendar Pal Singh, Dehra Dun, India.

Balick, M. & P. A. Cox. 1996. *Plants, People, and Culture: The Science of Ethnobotany.* Scientific American Library, New York.

Cotton, C. M. 1997. Ethnobotany – Principles and Applications. John Wiley and Sons Limited. New York, USA

CSIR. 1940 - 1976. Wealth of India. A Dictionary of Raw Materials and Industrial Products - Raw Materials. Vol.1-11. CSIR Publication & Information Directorate. New Delhi.

Cunningham, A.B. 1993. Ethics, Ethnobiological Research, and Biodiversity. WWF. International Publication. Switzerland.

Cunningham, A.B. 2001. Applied Ethnobotany. Earthscan Publications Ltd.

David, N & C. Kramer. 2001. Ethnoarchaeology in Action. Cambridge University Press, New York.

Duthfield, G. 2004. Intellectual Property, Biogenetic Resources and Traditional Knowledge. Earthscan, London, UK.

Jain, S.K. 1989. Methods and Approaches in Ethnobotany. Society of Ethnobotanists. Lucknow.

Jain, S.K. 1991. Contributions to Indian Ethnobotany. Scientific Publishers. Jodhpur.

Jain, S.K. 1991. Dictionary of Indian folk medicine and Ethnobotany. Deep Publishers. New Delhi.

Jain, S.K. & V. Mudgal. 1999. A Handbook of Ethnobotany. Bishen Singh Mahendra Pal Singh, Dehra dun.

Kate, K. T.,& S. A. Laird. 2000. Commercial Use of Biodiversity. Earthscan, London, UK

Laird, S.A. 2002. Biodiversity and Traditional knowledge Equitable partnerships in Practice. Earthscan Publications Ltd., London.

Martin, G. J. 2004. Ethnobotany: a methods manual. Earthscan.

Pei Shengii, Su Yong-Ge, Long Chun-Lin, M. Ken & D.A. Posey. 1996. The Challenges of Ethnobiology in the 21st Century. Kunming Institute of Botany. China.

Rastogi, R.P., & B.N. Mehrotra. 1993. Compendium of Indian Medicinal Plants. Vol.I & Vol. II. CSIR. Lucknow. Publications and Information Directorate. New Delhi.

Schultes, R.E., & S.V. Reis.(Eds.). 1995. Ethnobotany. Evolution of a discipline. Chapman & Hall. London.

Simpson,B.B., & M.C. Ogorzaly. 1986. Economic Botany. Plants in Our World. McGraw Hill Company. New York.

Singh, K.S. 1998. India's Communities. Oxford University Press, Delhi. Vols. I –VI.

UNDP. 1994. Conserving Indigenous Knowledge. Integrating Two Systems of Innovation. Rural Advancement Foundation. Commissioned by UNDP.

Wong, J.L.G., K. Thornber And N. Baker. 2001. Non-wood forest products. Resource assessment of non-wood forest products. Experience and biometric principles. Food and Agriculture Organization, (FAO), Rome.

BACK

BOO-203: Mycological Techniques **(60 hours, four credits)**

(Theory 45 hours, three credits; practicals 15 hours, One credit)

Theory Syllabus (45 hours, three credits)

Fungi in field

Fungi in ATBI-protocols and work by Amy Rossman; Fungi in their natural habitats, Identification of tropical fungal habitats and nutritional modes in field (biotrophy, nectrotrophy, saprotrophy), techniques for various sample collection from terrestrial and aquatic habitats, sampling for extremophiles, field documentation, outdoor photography and videography of fungi in their natural habitat; use of GPS and satellite images for geoindexing/georeferencing, sample processing in field and in laboratory; special samples-fungi in stratosphere, aeromycological techniques-indoor and outdoor environment, sampling fungal human pathogens, Collection and processing of environmental samples for fungal metagenomics (15 h)

Mycotaxonomic techniques

Fungal systematics; identification techniques; taxonomy and classification; use of criteria for fungal identification, use of taxonomic keys for identification; Mycological Herbarium, fungal cytochemistry, action of different mountants and stains; preparing good stained and unstained preparations for microscopic studies, recording of taxonomically distinct characters, preparing taxonomic diagnosis; art and science of mycological drawings, photomicrography and fungal digital image analysis, specimen preparation for fluorescence, SEM and TEM, chemotaxonomic techniques; electronic keys and mycological databases, numerical and computer taxonomy; Chemo- and molecular taxonomy; molecular markers, fungal isozymes; the fungal holomorph; fungal gene banks; introduction to culture collections, culture databases, culture maintenance (12 h)

Fungal cultural techniques

Various techniques for pure culture isolation and maximum recovery from different habitats; baiting, moist-chamber and particle-plating techniques, formulation of different media, purification and maintenance of cultures,; techniques for short term and long term maintenance of cultures; study of colony characters, growth, differentiation, cultural micromorphology and taxonomy; hyphal analysis; techniques for conidial ontogeny; use of fractal biology to study colony ontogeny; fungal cultural characters on solid and in liquid media; fungal morphotypes; microscopic and enzymological characterization, identification of interesting strains; special techniques for anamorphs and teleomorphs, micromanipulation and use of micromanipulators, techniques to get single spore cultures; mating techniques for testing somatic compatibility; production of protoplasts; growth in stationary and liquid culture; effect of pH, temp, light and humidity, study of submerged biomass (pellets) and culture filtrate; fungal photophysiology and chronobiology; screening for antibiotic production; basic techniques in fungal molecular biology (DNA, RNA, protein mini-prep), applications of PCR in mycology, mycoinformatics (18 h)

Practicals (**About 10 from the list, 15 hours, One credit)**

1. Collection of fungal samples from diverse habitats and recording of field data, Preparation of mycological herbarium
2. Fungal ramification of plant litter and litter degradation rates
3. Use of different stains and optical brighteners in mycology
4. Photomicrography of interesting fungi, digital image analysis, taxonomic drawings using drawing tube
5. Isolation of cultures from diverse samples and their characterization
6. Use of fungal taxonomic keys and electronic databases, writing a taxonomic diagnosis
7. Somatic pairing tests
8. Evaluation of colony growth on solid and in liquid media at different temperature and pH
9. Analysis of submerged biomass and culture filtrate from shaken cultures
10. Hemocytometric counts of fungal spores
11. Measurement of hyphal growth rate and Fractal dimensions of colonies
12. Use of micromanipulator for single spore isolation
13. Fungal protoplast production, fusion and regeneration using commercial lytic enzymes
14. Effect of light on growth of fungal cultures and pigment production
15. Antibiotic assays
16. Dermatophyte test medium to sample fungal human pathogens
16. Studying cultural holomorphs (anamorph-teleomorph connection) in lab
17. Extraction of fungal DNA, RNA, Proteins
18. RAPD of diverse fungal cultures

Recommended References:-

1. S. Sundar Rajan (2000). Practical Manual of Fungi, Anmol Publications, new delhi
2. Nair, L.N. (2007). Topics in Mycology and Pathology, new central Book agency, Kolkata
3. E.W. Koneman , G.W. Roberts (1985).Practical laboratory Mycology, Williams and Wilkins
4. A. Johnston and C. Booth (1983). Plant pathologist's pocketbook, CAB, UK
5. C. Booth (1971). Methods in Microbiology, Volume 4, Academic Press
6. E. Glyn V. Evans and M.D. Richardson (1989). Medical Mycology : A practical approach, IRL Press
7. Bridge, P.D. (1998). Applications of PCR in Mycology, CABI, UK
8. Manuel A. S. Graça, Felix Bärlocher, Mark O. Gessner (2005). Methods to study litter decomposition: a practical guide, Springer
9. Maheshwari, Ramesh (2005), Fungi: experimental methods in biology, CRC Press
10. Rossman Amy R. (1998). Protocols for an all taxa biodiversity inventory of fungi in a Costa Rican conservation area, Parkway Publishers, Inc.
11. Oliver R. P. and Michael Schweizer (1999). Molecular fungal biology, CUP
12. Berry D. R. (1988). Physiology of industrial Fungi, Blackwell scientific publishers
13. Moore David and LilyAnn Noval Frazer (2002). Essential Fungal genetics, Springer.
14. Harry J. Hudson (1986). Fungal biology, ELBS/Edwin Arnold, UK
15. Deacon, J.W. (1984). Introduction to Modern Mycology, ELBS, Blackwell scientific publications
16. Hawksworth, D.L, P.M. Kirk, B.C. Sutton and D.N.Pegler (1995). Ainsworth and Bisby's Dictionary of the fungi, 8th edition,, CAB international
17. Heather Angel (1975). Photographing Nature-Fungi, Fountain press, UK
18. J.D. Desai and A.J.Desai (1980). Methods in Microbiology-Microscopy and Staining, Prashant Pub.
19. Bhat, D. J. (2010). Fascinating Microfungi (hyphomycetes) of western ghats-India, Broadway Book Centre, Goa
20. Sathe A.V., Deshpande S. , Kulkarni, S.M. and J. Daniel (1980). Agaricales (mushrooms) of south west India, MACS, Pune.

BACK

BOO-301 APPLIED PHYCOLOGY: UTILIZATION AND MANAGEMENT

1. ALGAE FOR FOOD AND FOOD SUPPLEMENTS:

a) Scientific basis and Techniques of Mariculture

b) Porphyra as food: Cultivation and economics: Food and other uses, development of cultivation methods, present and future trends.

c) Cultivated edible kelps: Edible products, kelp composition, kelp production methods, world production

d) Food and food products from seaweeds.

e) *Spirulina* as human food: Nutritional aspects. Economic and environmental aspects. Theraupetic applications, Harvesting wild populations, Village scale production.

f) Some public health aspects of microalgal products. Pheophorbide, Microbial contamination, Extraneous materials, metals, organic compounds, Maintaining sanitary quality.

2. ALGAE: IN INDUSTRY, ENVIRONMENTAL MANAGEMENT AND AGRICULTURE:

a) Commercial production and application of algae: Hydrocolloids History, Chemistry production and Application, future aspects of alginates, Carrageenans, Agars.

b) Lipids and polyols from microalgae History of microalgal lipid production research, Triacylglycerots, Hydrocarban, algal solar energy conversion, carotenoids Polyols.

c) Microalgae in liquid waste treatment and reclamation. Biological waste treatment system, Design consideration (Algal concentration, algal productivity) Operation of integrated algal bacterial system, current application, future application (Sewage grown algae, energy system, toxin removal, integrated feedlots).

d) Hydrogen production by algae: water splitting Role of algae in hydrogen production, principles of photosynthetic hydrogen production, Bio-photolysis of water.

e) Products from fossil algal: Diatomite-industrial mineral, Calcareous algae, Algal organics and Bio-stratography: algal kerogen in petroleum and coal, Bio-stratiography.

f) Algae & Agriculture: Free living cyanobacteria and algalization, *Azolla*, Microalgal soil conditioners, Microalgal plant growth regulation, Seaweed use in agriculture and horticulture

3. ADVERSE IMPACTS OF ALGAE

a) Marine dinoflagellates blooms: dynamics and impacts: Bloom dynamics: Initiation, growth, maintenance, Termination, Ecological and Economic impacts: Negative & Positive impacts.

b) Hazards of freshwater blue green algae (Cyanobacteria) Neurotoxins, Hepatotoxins, other toxins, Medicinal aspects; Human poisoning, contact dermititis

c) Marine biofouling: Bacterial, Microalgal & Macroalgal biofouling, control treatments; antifouling coatings. Recent improvements in chemical control Methodology, Biological control, Non-adhesive surfaces.

4. FUTURE OF ALGAE WITH MANKIND

a) Algae in space: Algae and life support systems; Algae and planetary biology, Future of algae in space.

b) Genetic improvement for algal resources

Practicals : Any 15 depending on the availability of resources will be conducted

1. Extraction of Phycocolloids (3P)
2. Seaweed resources of India (2P)
3. Preparation of BGA fertilizer (4 Practicals)
   a) Preparation of media and inoculation (2P)
   b) Preparation of Open air shallow culture (1P)
   c) Multiplication of BGA (1P)
4. Sampling methods for fresh water Phytoplankton (1P)
5. Study of marine harmful algal species (3P)
6. Sampling methods and fixation techniques (1P)
7. Measurement of Biomass (1P)
8. Identification of marine phytoplankton bloom forming groups (1P)
9. Study of micro and Macro fouling species (2P)
10. Algae from ballast water (1P)
11. Fossil algae (1P)

Visit to Institute; Field visits

REFERENCES:

Dawson E.Y. 1966 Marine Botany.

Lobban C.S. 1985. The Physiological ecology of Seaweeds.

Lewin K.W.J.C. 1962. Physiology and Biochemistry of Algae.

Lembi C.A. 1988. Algae and human affairs.

Chapman V.J. and Chapman D.J.(1975). *The algae*, 2nd Edition, Mac. Millan Publ. Inc. New York

Alexander I. Railkin (2004). Marine biofouling: colonization processes and defenses. CRC Press LLC

Hans-Curt Flemming, P. Sriyutha Murthy, R. Venkatesan (2009). Marine and Industrial Biofouling. Springer Verlag Berlin Heidelberg

S. W. Dean, Guillermo Hernandez-Duque Delgadillo, James B. Bushman.(2000). Marine corrosion in tropical environments. American Society for Testing and Materials, West Conshohocken, PA

D. Féron, (2001). Marine corrosion of stainless steels. Snippet view

Linda E. Graham, James M. Graham, Lee Warren Wilcox (2009). Algae. Benjamin Cummings

6.David M. Mousdale (2008). Biofuels: biotechnology, chemistry, and sustainable development. Taylor & Francis Group, LLC

Oskar R. Zaborsky (1998). Biohydrogen. Plenum Press, New York

Craig A. Grimes, Oomman (2008). Light, water, hydrogen: the solar generation of hydrogen by water. Springer Science + Business Media, LLC

Ayhan Demirbas (2008). Biofuels: Securing the Planet's Future Energy Needs. Springer – Verlag London Limited

Robert Edward Lee (1999). Phycology (*SPIRULINA*). Cambridge University Press

Raina M. Maier, Ian L. Pepper, Charles P. Gerba (2009). Environmental microbiology (*SPIRULINA*). Elsevier Inc. Publisher

Harald W. Tietze (1999). Spirulina Micro Food Macro Blessings, Harald W. Tietze Publisher

E. Wolfgang Becker (1994). Microalgae: biotechnology and microbiology, Cambridge University Press

P. M. Dey, Jeffrey B. Harborne (1997). Plant biochemistry, Academic Press

Physiology, Ecology, and Toxic Properties of Marine Cyanobacteria Blooms

- Kevin G. Sellner
- *Limnology and Oceanography*, Vol. 42, No. 5, Part 2: The Ecology and Oceanography of Harmful Algal Bl... more
- Published by: American Society of Limnology and Oceanography

BACK

BOO-302: PLANT BIOTECHNOLOGY. 4 credits (3+1)

1. Plant Tissue Culture: Totipotency; A brief history of plant tissue culture; chronology of important developments in plant tissue culture; General Techniques; Laboratory Organisation; Media Composition and Preparation, Aseptic Manipulation; Cell Cultures (including Bergmann's plating technique); Application of cell culture (Mutant selection, production of secondary metabolites, transformations). 8h
2. Application of Plant cell, tissue and organ cultures: Applications in agriculture – improvement of hybrids, encapsulated cells, production of disease and stress resistant plants. Applications in horticulture and Forestry – Micropropagation, Secondary metabolites from cell cultures, from immobilized plant cells. 6h
3. Micropropagation and somaclonal variation: Clonal propagation or micropropagation; Mechanism of somaclonal variation, Role of somaclonal variation in plant breeding; Applications. 4h
4. Germplasm conservation and Cryopreservation: Modes of Conservation, significance; Cryopreservation: Cryopreservation of plant stock cells - Methods of cryopreservation, cryobank, Pollen bank; Prospects in agricultural and forest biotechnology. 5h
5. Production and uses of Haploids: Production of haploids (anther culture, ovule culture, bulbosum technique), detection of haploids (morphology, genetic markers); uses of haploids; Pollen as a tool in crop improvement; Pollen storage; Effect of radiation on pollen. 6h
6. Protoplast culture, regeneration and somatic hybridization: Isolation of protoplasts, Purification of protoplasts, viability and plating density of protoplast; protoplast culture and regeneration of plants; protoplast fusion and somatic hybridization, Cytoplasmic hybrids or hybrids, genetic modification of protoplasts. 6h
7. Transgenic Plants: Transgenic plants and crop improvement; Selectable marker genes and their use Molecular pharming, Bioethics in plant genetic engineering. Target cells for transformation, Selectable and scorable markers (reporter genes), Methods of direct gene transfer. 5h
9. Application of plant biotechnology in agriculture, forest and human welfare. Applications in industries, (enzymes Biotechnology). Biofertlizers, *in vitro* establishment of Mycorrhiza (microbial bioinoculants), Biopesticides, Environmental Biotechnology, Nanobiotechnology. 5h

PRACTICALS:

1. Familiarizing with various physical and chemical sterilization techniques.
2. Preparation of solid and liquid nutrient media.
3. Preparation of explant and inoculation.
4. Study of callus morphology.
5. Technique of sub culturing the callus.
6. Preparation of differentiation media.
7. Inoculation of the callus on differentiation media and regeneration of explants.
8. Preparation of media for anther culture and inoculation.
9. Preparation of media for pollen culture and inoculation.
10. Preparation of cell suspension cultures.
11. Study of cell viability methods.
12. Isolation of protoplast.
13. Study of protoplast viability.
14. Root organ culture (ROC) technique.
15. Preparation of artificial/synthetic seeds (alginate beads).

REFERENCE BOOKS

1. Aguilar Cristobel Noe (2008) Food Science and Food Biotechnology in Developing countries. Asiatech Publishers Inc.

2. Prasad (2008) Biotechnology In Sustainable Biodiversity And Food Security. India Book House Limited.

3. Vibha Dhawan (2008) Biotechnology For Food And Nutritional Security. Teri Press.

4.Bhojwani, S.S., Razdan, M.K. (1997) Plant Tissue Culture: Theory and Practice. Springer Publishers Netherlands.

5. Rajmohan Joshi (2006) Agricultural Biotechnology. Gyan Books.

6. H D Kumar (2005) Agricultural Biotechnology. Daya Publishing House.

7. H Gautam (2006) Agricultural & Industrial Applications of Bio-technology. Rajat Publication.

8. V S Harikumar (2006) Advances in Agricultural Biotechnology. Regency Publishers.

9. Bhavneet Kaur, C.P. Malik & Chitra Wadhwani (2008) Current Topics in Biotechnology. M.D. Publications, New Delhi.

10. R. C. Dubey (2009) A text book of Biotechnology. S. Chand & Co. Ltd. New Delhi.

BACK

BOO-303 MYCORRHIZAL BIOTECHNOLOGY (30L) (3 Credits) 2+1

1. Biofertilizers: Definition, types, characteristic features, their role and importance in sustainable agriculture. **(2L)**
2. Mycorrhiza – Definition and historical perspective; general importance; Types of mycorrhize – Endomycorrhizae, Ectomycorrhizae, Ect-endomycorrhizae, Ericoid, Orchid and Arbutoid mycorrhizae. **(2L)**
3. Classification of Ecto- and Endo- mycorrhizae; Taxonomy and Phylogeny. **(2L)**
4. Molecular and cell biology of AM symbiosis: Fungal partner; Model plants in AM research; Cytological features of AM plant roots; Root to fungus signaling in AM symbiosis – Asymbiotic phase, presymbiotic phase and symbiotic phase; Fungus to root signaling in AM symbiosis – Presymbiotic phase and symbiotic phase; Transfer of nutrients between plants and fungi; Defense reaction during colonization; Signaling pathways in AM fungi. **(4L)**
5. Phosphate in AM symbiosis – Transport properties and regulatory roles: Phosphorus uptake from environment; Plant phosphate transporters; Phosphate transport in AM fungus; AM symbiosis and plant phosphate transport; Phosphate and nitrogen interdependency. **(3L)**
6. Role of Phytohormones in AM symbiosis: Cytokinins, Gibberellins, Ethylene, ABA, Auxins, Salicylic acid, Jasmonic acid; Role of Jasmonates in mycorrhization **(2L)**
7. Techniques in Mycorrhizal Research: Isolation and pure culture preparation of ecto- and endo-mycorrhizae; Taxonomic identification; Staining techniques; Trap cultures; *in vitro* culture of AM fungi. **(3L)**
8. Transport processes in AM fungi: Carbon transport in AM fungi; storage lipid translocation in AM fungi; global nutrient fluxes in AM fungi; Mechanisms for regulating nutrient translocation. **(2L)**
9. Mycorrhizal technology for sustainable agriculture, horticulture and forestry: Effect of phosphorus deficiency in plant development; Phosphorus uptake strategies and effectiveness in plants; Soil temperature and P supply; fertilizer management. Formulation of ectomycorrhizal bioinoculants – A case study. Formulation of AM bioinoculants – A case study. **(4L)**
10. Ecology of Mycorrhizae: Mycorrhiza formation in field soils; distinguishing fungi within roots; modeling mycorrhiza formation in mixed communities; disturbance effects on fungal diversity. **(3L)**
11. Mycorrhizae in phytoremediation of mining areas and polluted soils: Mycorrhizae in heavy metal contamination; phytostabilization; phytoextraction; concepts for improving phytoremediation by plant engineering. **(3L)**

PRACTICALS:

1. Isolation of AM fungal spores from rhizosphere soil.

2. Estimation of AM fungal spore numbers.

2. Techniques of staining roots for AM colonization.

3. Histochemical staining for polyphosphate granules in AM fungal hyphae using Toluidine blue O (TBO).

4. Histochemical staining for lipid bodies in AM fungal hyphae and vesicles using Sudan Black. .

5. Preparation of AM fungal cultures.

6. Identification of some commonly occurring AM fungal species based on spore morphlogy.

REFERENCE BOOKS

1. Allan, M. F. 1991 The Ecology of Mycorrhizae. Cambridge University Press.
2. Bacon, C. W. and White, J. H. 2000. Microbial Endophytes Marcel Dekker, New York.
3. Dwivedi, B. K. and Pandey, G. 1994. Biotechnology in India. Allahabad: Bioved Research Society.
4. Read, D. J., Lewis, D. H. Fitter, A. H. and Alexander, I. J. 1996 Mycorrhizas in Ecosystems. Oxford University Press.
5. Rodrigues, B. F. and Muthukumar, T. 2009. Arbuscular Mycorrhizae of Goa – A Manual of Identification Protocols. Goa University, Goa. 135 *pp*.
6. Schenck, N. C. 1982. Methods and principles of mycorrhizal research. St. Paul Minnesota.
7. Schenck, N.C. and Perez, Y. 1990. Manual for the identification of VA mycorrhizal fungi. International Culture Collection of VA Mycorrhizal Fungi. Synergistic Publications, Gainesville, Florida, USA.
8. Sylvia, D. M., Hung, L. L. and Graham, J. H. 1987. Mycorrhizae in the next Decade, Practical Applications and Research Priorities. University of Florida. Gainesville, Florida.

BACK

BOO-304: Plant Histochemistry (3 Credits) 2+1

8. Introduction to basic histology - Cells and tissues and microorganisms. (1h)

9. General Techniques: Chemistry and practice of fixation; whole mounts; sectioning- microtomy, cryo and ultra-microtomy; freeze-drying of biological materials. (2h)

10. Microscopy: Light matter interaction and its significance; Kohler illumination; Principles, instrumentation and applications of bright-field, polarization, phase-contrast, fluorescence, confocal, scanning and transmission electron microscopy; image analyzing system. (8)

11. Cyto and histochemistry with bright-field microscopy: Single and double staining protocols; localization of various biogenic components such as carbohydrates, proteins, lipids, nucleic acids, phenolic compounds, lignins, cutins, suberin, waxes, minerals such as calcium, potassium, irons and other metals. (3h)

12. Polarization microscopy: Study of structure and components of cell wall, starch, crystals and other anisotropic materials. (1h)

13. Fluorescence microscopy: Auto-fluorescence in biological materials; fluorochromes; excitation filters; localisation of proteins, lysine rich proteins, lipids, nucleic acids, phytins, phenolic compounds, lignins and cutins in various biological tissues using fluorescent dyes; Role of FITC-bound dextrins and vascular tissue specific fluorochromes in biology; study of cell membranes, connective tissues, protoplasts and infected materials. (4h)

14. Electron microscopy: Specimen preparation for TEM and SEM. (1h)

15. Enzyme histochemistry: Localization of esterases; phosphates and other enzymes. (2h)

16. Microphotography: Basic techniques of image capturing and image analysis using bight-field, polarization, dark-field and fluorescence microscopy; Macrophotography: Conventional and digital photography; basic principles, cameras, lenses, focusing, exposure, resolution, depth of field, lighting, keeping and storing records. (4h)

17. Cyto-histochemistry and its applications: Understanding biological structures of microorganisms, fungi, algae, medicinal and other economically important plants; Applications in diagnostic and analytical sciences and biotechnology. (4h)

Practicals (15h) (Any 10 practicals)

1. Study of auto-fluorescence in biological specimens using UV, violet, blue and green excitation filters under fluorescence microscopy.
2. Localization of proteins in biological tissues using fluorescent and non-fluorescent dyes.
3. Localization of lipids in biological tissues using fluorescent and non-fluorescent dyes.
4. Study of cell wall structure using the specific fluorochrome like calcofluor white or acridine orange using fluorescence microscopy.
5. Study the distribution of starch in biological specimens using iodine potassium iodide.
6. Study the structure of starch, stomata, crystalline and other anisotropic materials using polarization microscopy.

7. Examination of normal and diseased plant or animal/human tissues using fluorescence microscopy.
8. Localization of nucleus using fluorescent and non-fluorescent dyes.
9. Localization of minerals such as calcium, potassium and iron in biological tissues.
10. Microphotography using bright-field, dark-field, polarization and fluorescence microscopy.
11. Macro and field photography using normal, zoom and macro lenses.
12. Study of standard microbiota: gram positive, negative bacteria, fungi, algae, protozoans.
13. Demonstration of image capture, image analysis, measurement of various parameters of cells and tissues using image analyzing software.
14. Demonstration of scanning electron microscopy.

Reference Books

1. Pears, A.G.E.1980. Histochemistry Theoretical and Applied, Preparative and Optical Techniques. Vol. I. Fourth Edition. Churchill Livingstone. London and New York.
2. Pears, A.G.E. 1985. Histochemistry Theoretical and Applied. Analytical Technology. Vol. II Churchill Livingstone. London and New York.
3. Krishnamurthy, K.V. 1988, Methods in Plant Histochemistry. S. Viswanthan (Printers & Publishers) PVT. LTD., Chennai.
4. Conn. H.J. 1977. Biological Stains. R. D. Lillie (Ed.) The Williams and Wilkins Co., Reprinted by Sigma Chemical Company, USA.
5. Clark, G. 1981. Staining Procedures, Williams and Wilkins, Baltimore, USA.
6. Jensen, W.A. 1962. Botanical Histochemistry Principles and Practice. W. H. Freeman and Company, San Francisco, USA.
7. Hayat, M.A. 1986. Basic Techniques for Transmission Electron Microscopy. Academic Press. London and New York.

BACK

BOO-305 Horticulture, Landscaping and Gardening 3 Credits (2+1)

1. Horticulture and its relation to agriculture, agronomy and forestry. History and importance of horticulture in food, medicine, spice, ornamentals and commerce. (2h)

2. Important families of horticultural plants as sources of vegetables, fruits, spices, ornamentals and landscaping plants. Classification of plants as annuals, biennials and perennials; herbs, shrubs, vines, climbers, trees and evergreens. (2h)

3. **Growth and Development:** Seed dormancy, viability and germination. Vegetative and reproductive growth of plants. Native and synthetic hormones and other growth regulators, their importance in horticulture, gardening and landscaping. (2h)

4. **Environment and Plant Growth:** Climatic factors and their effects on plant growth and development. Importance of water, temperature and light quality and quantity. Greenhouse and other plant growing-structure. (2h)

5. **Irrigation:** Advanced irrigation system such as drip, microtube and sprinkler systems. (2h)

6. **Soils and mineral requirements:** Importance of macro and micronutrients in plant growth and development. Nature and importance of soil, different types of soil. Sterile soil mixtures (vermiculite, perlite etc., hydroponics). Different types of organic manure's and inorganic fertilizers. (2h)

7. **Propagation of plants:** Vegetative propagation using stem, leaf and root cuttings. Propagation by division and layering, bulbs, corms, tubers and rhizomes, budding and grafting. Production of seeds, their certification, storage and germplasm collection. Tissue culture and micro propagation and genetically modified plants. (2h)

8. Important vegetables and fruits, their countries of origin cultivation and importance in Indian trade and economy. Nutritive value of vegetables greens and fruits. Cultivation of spices and medicinal plants. (3h)

9. **Pests and Diseases:** Viral, mycoplasmic, bacterial and fungal pathogens and insects and pests of horticultural plants. Insecticides, pesticides; biological control and integrated pest management. (3h)

10. **Gardens and Gardening:** Design of gardens for vegetable and fruit-plant cultivation. Flower gardening. Special methods of ornamental cultures such as hanging baskets, bottle and terrarium gardening, roof, rock and water gardens. Bonsai and topiary. (5h)

11. **Aesthetics of horticulture:** Elements and principles of design and landscape architecture; formal and informal gardens of the world in general and India in particular. Flower beds, borders, lawns, hedges, edges and topiary. (5h)

Practicals (Any 15 practical)

1. A knowledge of tools, techniques and terminologies of horticulture such as rake, hoe, spade, trowel, digger, shoval, pick-axe, mamti, plantlet, budding, staking, mulching, thinning, pruning and grafting.
2. Knowledge of local climatic conditions and planting seasons of horticultural plants.
3. Preparation by cutting and layering. Use of auxins for rooting and grafting.
4. Planning and planting a vegetable garden with local seasonal vegetables. Maintenance of a record of their growth.
5. Knowledge of common vegetables, fruits and flowers of India and their countries of origin. Wild edible plants. Seeds, plants, chemicals and equipment for horticulture.
6. Observation of common diseases and insect pests of horticultural plants around Goa. Knowledge of common herbicides, fungicides and insecticides locally available.
7. Collection and identification of 10 insect pests of horticultural plants.
8. Field trips, when possible to places of horticultural gardens and landscaping areas and studios.
9. Hedge plants of Goa.
10. Ornamental flowering plants of Goa.
11. Foliage plants of Goa.
12. Ferns of Goa.
13. Flowers sold in Goa.
14. Vegetables of Goa market and their origin.
15. Botanical garden in Goa.
16. Common wild edible plants of Goa.
17. Caning of vegetables and fruits.

Reference Books

1. Adams, C.R., K.M.Banford and M.P.Early. 1990. Principles of Horticulture, Butternorth Heineman Ltd. London.
2. Gopalan, C., B.V. Rama Sastri, S.C. Balasubramanian, B.S. Narasinga Rao, Y.G. Deosthale and K.C. Pant. 1996. Nutritive value of Indian foods. National Institute of Nutrition (ICMR), Hyderabad, India.
3. Graf, A.B. 1981. Tropica, 2nd edition, Rohers Co. USA.
4. Hariman, H.T. and D.F. Kestler. 1976. Plant propagation: Principles and practicals. Prentice & Hall of India. New Delhi.
5. Kumar, N. 1986. Introduction to Horticulture. Rajalakshmi Publication. Nagerkoil, Tamil Nadu.
6. Moore, R. & W.D. Clark.1995. Botany: Plant form & function, Vol.1.W.M.C.Brown Publisher.
7. Randhawa and A. Mukhopadyay. 1982. Floriculture in India. Allied Pub. Pvt. Ltd. New Delhi.
8. Ranjit, S. 1992. Fruits. 2nd National Book Trust. New Delhi.
9. Rao, K.M. 1991. Text book of Horticulture. MacMillan India Ltd. New Delhi.
10. Torres, C. K. 1989. Tissue culture techniques for horticulturalcrops. Van Nostrand Reinheld. New York.
11. Commercial Floriculture in Goa. Agricultural Officer's Association – Goa. 2002.
12. Manual of Gardening. Agricultural Officer's Association – Goa. 1997.
13. Agribusiness Opportunities in Goa. Agricultural Officer's Association – Goa. 2000.
14. Kitchen Garden Manual. Agricultural Officer's Association – Goa. 2000.

BACK

BOO-401: Fungal Chemistry and Mycoremediation Total credits:-2
Total credits:- (Theory- 1, Practicals -1)
Fungal Chemistry and Mycoremediation
Theory 15 lectures, One credit

I. Fungal Metabolites Derived from Amino Acids Introduction, Penicillins,Cephalosporins, *b*-Lactams, Mycelianamide, Gliotoxin, The Cyclopenin-Viridicatin Group of Metabolites,Tryptophan-derived Metabolites, Glutamic Acid Derivatives, Fungal Peptides (02)

II. Polyketides and Terpenoids from Fungi:- Polyketide Biosynthesis, Triketides,Tetraketides, 6-Methylsalicylic Acid, Patulin and Penicillic Acid, Gladiolic Acid and itsRelatives, Tetraketide Tropolones, Mycophenolic Acid, Pentaketides, Citrinin,Terrein ,Hepta- and Octaketides:-Griseofulvin, Cladosporin (Asperentin); PolyketideLactones, Statins , Cytochalasins , Fatty Acids from Fungi , Polyacetylenes from theHigher Fungi, Biosynthesis of Fungal Terpenoids, Monoterpenoids, Sesquiterpenoids, Diterpenoid Fungal Metabolites, Sesterterpenoids, Fungal Triterpenoids and Steroids, Ergosterol, Fusidane Steroidal Antibiotics, Viridin, Wortmannin and their Relatives, Triterpenoids of the basidiomycetes, Meroterpenoids (02)

III. Fungal Metabolites Derived from the Citric Acid Cycle:-Introduction, Citric Acid and Related Acids, Fungal Tetronic Acids, Canadensolide and Avenaciolide, Nonadrides, Squalestatins (01)

IV. Pigments and flavours from Fungi:- Introduction, Polyketide Fungal Pigments,Fumigatin, Auroglaucin and Flavoglaucin, Hydroxyanthraquinone Pigments,Xanthone and Naphthopyrone Pigments, Extended and Dimeric Quinones, Fungal Pigments Derived from the Shikimate Pathway, Terphenyls, Pulvinic Acids, Some Pigments Containing Nitrogen, Fungal Carotenoids, Lichen Substances, flvaours from fungi, Organoleptic Components of Mushrooms, (02)

V. Mycotoxins:-Introduction, Ergotism, Trichothecenes as Mycotoxins, Other Fusarium Toxins, Aflatoxins, Mycotoxins of Penicillium Species, PoisonousMushrooms (01)

VI. Fungal Biodegradation and Biodeterioration:- Fungi as Environmental Indicators, Methods for Detection of Degradative Fungi, Mycoremediation: Fungal Bioremediation, White-Rot Fungi in Bioremediation, Ecology of Mycoremediation, Genetic Engineering of Mycoremediation (02)

VII. Fungal Treatment of Industrial Wastewaters, Distillery and Brewery Wastes (01)

VIII. Fungal Metabolism of Petroleum Hydrocarbons, Phenols, Chlorophenols, Pentachlorophenol, Polycyclic Aromatic Hydrocarbons (01)

IX. Fungal Degradation of Polychlorinated Biphenyls and Dioxins, Pesticides (01)

X. Fungal Lignin Degradation, Decolorization of Pulp and Paper Mill Effluents, Decolorization and Degradation of Dyes (01)

XI. Fungal Biosorption of Heavy Metals (01)

Fungal chemistry and Mycoremediation

Practicals , 15 hours, One credit

1. UV and FTIR Spectrosopic analysis of representative fungal cultures
2. Extraction of fungal melanin
3. Extraction of organic acids from yeasts and fungi
4. Microincineration technique for detecting calcium oxalate from fungi
5. Detection of fungal alkaloids from culture filtrates
6. Determination of sterols in yeast by LB method
7. Detection of soluble beta glucans from yeasts using FTIR
8. Extraction of fungal quinonoid pigments
9. Bioassay for detection of antibiotic activity
10. Total and differential count of fungi from soils, sediments etc.
11. Isolation of Fungi involved in biodeterioration
12. Isolation of fungi from industrial wastewaters
13. Detection of fungal hydrolytic enzymes e.g. Chitinases, Chitosanase, cellulases, amylases, proteases, ureasse, lipases, esterases etc.
14. Evaluation of Fungal growth in standard petroleum hydrocarbons
15. Fungal growth on polluting tar balls and polystyrene foam
16. Fungal biodecolourization of common textile dyes
17. Using fungal biomass for biosorption of Iron

References:-

1. Hanson, James . (2008). The chemistry of fungi, Royal Society of Chemistry, 221 pp.
2. Harbhajan Singh. (2006) Mycoremediation: Fungal bioremediation, Wiley, 608 pp.
3. Claudio Toniolo , Hans Brockner (Editor) (2009) Peptaibiotics: Fungal Peptides Containing alpha-Dialkyl alpha-Amino Acids , Wiley-VCH, 714 pp.
4. Frisvad (1998), Chemical fungal taxonomy, CRC press, 424 pp.
5. B. Volesky (1990). Biosorption of heavy metals, CRC press, 408 pp.
6. Milbra A. Schweikert, Bruce B. Jarvis (Eds.) (2003). Handbook of Secondary Fungal Metabolites, 3-Volume Set , Academic Press, 2498 pp.
7. P. J. Kuhn (1990). Biochemistry of Cell Walls and Membranes in Fungi, Springer, 327 pp.
8. G. D. Robson , Pieter van West, Geoffrey Gadd (Eds.) (2007). Exploitation of Fungi (British Mycological Society Symposia), CUP, 350 pp.
9. G. M. Gadd (Editor) (2001). Fungi in Bioremediation (British Mycological Society Symposia), CUP, 496 pp.
10. Valdes J.V. (2000). Bioremediation, Springer, 169 pp.
11. Zhigiang an (2005). Handbook of Industrial Mycology, CRC Press, 763 pp.
12. S.K.deshmukh, M.K.Rai (2005). Biodiversity of fungi: their role in human life, Science Publishers, 460 pp.
13. G.M. Gadd (2006) Fungi in biogeochemical cycles, Volume 24 of British Mycological Society symposium series, CUP, 406 pp.

BACK

BOO-402: Techniques in Photosynthesis and crop productivity (30 h) 2 credits

1. Plant growth analysis: Basic principles and classical growth analysis
2. Plant microclimate: Radiation, temperature, humidity, wind, plant water and soil status, canopy structure, shoot morphology and leaf anatomy and productivity.
3. Measurement of carbon dioxide assimilation by plants in the field and laboratory; Infra-red gas analysis, 14C incorporation etc.
4. Measurement of oxygen evolution and chlorophyll fluorescence; measurements of oxygen evolution for studying electron transport in isolated chloroplasts and mitochondria and other photoautotrophic. Chlorophyll fluorescence measurement and its interpretation.
5. Carbon metabolism: Assay of some enzymes of carbon reduction cycle.
6. Nitrogen metabolism: Measurement of nitrogen fixation by direct means and indirect assay of nitrogenase activity, assimilatory nitrogen reduction and determination of enzymatic activities, Ammonia assimilation.
7. Algae: Laboratory techniques and out door biomass production.
8. Measurement of plant biomass and net primary production: Sampling; Design; measuring of above ground and below ground biomass; non-destructive measurement of biomass, estimation of stem and leaf dimension and remote sensing.

Reference Books:

1. Charles-Edwards D.A. Physiological determinants of crop growth. Academic Press, London
2. Evans G.C. The quantitative analysis of Plant Growth. Blackwell Scientific, Oxford.
3. Hunt R. Plant Growth analysis. Studies in biology. Edward Arnold, London
4. Sestak Z., Catsky J and Jarvis P.G. Plant Photosynthetic production. W. Junk, Hague.
5. Johnson C.B. Physiological processes limiting plant productivity. Butterworths, U.K.
6. Monteith J.L. Vegetation and atmosphere. Academic Press. London
7. Woodwards F.I. and Sheehy J.E. Principles and measurements in environmental biology. Butterworths, London
8. Jones H.G. Plants and Microclimate. Cambridge.
9. Grace J. Plant Atmosphere relationships. Outline studies in ecology. Chapman and Hall, London.
10. Beadle C.L., Long S.P., Imbamba S.K., Hall D.O. and Olembo R.J. Photosynthesis in relation to plant production in terrestrial environments. Tycooly International, Oxford.
11. Nobel P.S. Biophysical Plant Physiology and Ecology. W.H. Freeman, San Fransisco.
12. Wit C.T. de. Photosynthesis of leaf canopies. Verslagen, Wageningen.
13. Meidner H. and Sheriff D.W. Water and Plants. Blackie, Glasgow.
14. Slavik B. Methods of studying plant water relations. Chapman and Hall. London.
15. Hill D.W. and Powell T. Non dispersive Infra-red gas analysis in science, medicine and industry. Adam Hilger, London.
16. Esau K. Anatomy of seed plants Wiley, New York.
17. Fahn A. Plant Anatomy. Pergamon, Oxford.
18. Edwards G.E. and Walker D.A. C3-C4 some aspects of photosynthetic carbon assimilation. Blackwell Scientific. Oxford.
19. Flores E., Ramos J.L., Herrero A and Guerrero M.G. Nitrate assimilation in cyanobacteria. Elsevier, New York
20. Paleg L.G. and Aspinall D. The physiology and biochemistry of drought resistance in plants. Academic Press. Sydney.
21. Carr N.G. and Whitton B.A. The biology of blue green algae. Balckwell. Oxford.
22. Fogg G.E. Algal culture and phytoplankton Ecology. Uni. Of Wisconsin Press. Madison.
23. Vogel J.C. Fractionation of the carbon isotopes during photosynthesis. Springer-Verlag, New York.

BACK

BOO-403: Phytochemistry **2 credits (1+1)**

1. Scope of Phytochemistry, its' importance in pharmaceuticals industry (1L)

2. Glycosides: definition, classification, therapeutic value, chemical properties & tests for identification. Phenolic Glycosides; Anthraquinone Glycosides- definition, natural sources, classification, relationships of anthraquinone derivatives, extraction, separation, characterization and pharmacological effects. Steroidal Glycosides; cardiac glycosides- definition, natural sources, classification & structures, SAR, chemical identification of the aglycone and the sugar moiety, therapeutic indication, toxicity and interactions). (3L)

3. Flavonoids (definition, natural sources, classification, biogenesis, extraction, isolation, identification and therapeutic applications) (1L)

4. Anthocyanins (definition, natural sources, classification, extraction, isolation, identification, therapeutic applications). (1L)

5. Coumarins (definition, natural sources, classification, biosynthesis, furanocoumrarins and pyranocoumarins pharmacological properties and phototoxicity); (1L)

6. Terpenes (definition, classification, biosynthesis, origin of 5-carbons isoprene unit, head to tail coupling and tail-to-tail coupling of isoprene units); Monoterpenes (definition, biogenesis, natural sources, classification, medicinal and non-medicinal uses); Sesquiterpenes (definition, biogenesis, natural sources, classification, pharmacological and toxicological effects); Diterpenes (definition, biogenesis, natural sources & classification, pharmacological and toxicological effects); Triterpenes (definition, biogenesis, natural sources, classification, pharmacological and toxicological effects) ;Tetraterpenes and Caretonoids (definition, natural sources, biogenesis, classification and therapeutic values). (4L)

7. Volatile Oils (definition, classifications, natural sources, medicinal and non medicinal uses); Saponins (definition, natural sources, classification, physical and biological properties) (2L)

8. Alkaloids (definition, classification, distribution in nature, localization, nomenclature, physico-chemical properties, extraction, detection, isolation, purification, biosynthetic origin and pharmacological activities) (1L)

9. Quinoline, tropane, pyridine, imidazole and indole alkaloids, isoquinoline, purine, steroidal and proto- alkaloid (1L)

Practicals (15 Nos)

Qualitative extimation of (1-4)

1. Hesperidin from Orange peel
2. Piperine from Piper nigrum
3. Caffeine from Tea leaves
4. Menthol from Mentha species
5. Determination of Anthracene derivatives in Senna by spectrophotometric method
6. Reserpine in Rauwolfia by photometric method
7. Citral content in Lemon grass oil
8. Quanititative estimation of Saponin as per W.H.O. protocol in suitable plant material
9. TLC of volatile oil samples
10. Phytohaematoglutinin activity of extract from seeds
11. Determination of Hyoscymine/Hyoscine in Datura species by UV. Spectroscopic method.
12. Quantitative estimation of Ephedrine in Ephedra extracts by HPTLC.
13. Quantitative estimation of glycyrrhizine in Glycyrrhiza glabra by HPTLC.
14. Exercises on Identification of simple Naturally occurring molecules by UV & IR spectroscopy.

Recommended books:-

1. Pharmacognosy, Phytochemistry, Medicinal plants
By Jean Bruneton (1995), English edition. Levoisier Publishing, Paris;

2. Natural products chemistry – Nakanishi Golo
3. Introduction to Molecular Phytochemistry by CHJ Wells. (Chapman and Hall)
4. Comparative Phytochemistry, edited by T. Swain.
5. Burger's medicinal chemistry edited by Alfred Burger.
6. Modern methods of plant analysis by Peach & M.V. Tracey, Vol. I to VII
7. Recent advances in Phytochemistry – Vol.I to IV scikel runeckles – Appletaon century crofts.

8. Chemistry natural products – Vol.I onwards IWPAC.
9. Natural products – A Laboratory guide by Raphel Ikhan
10. The essential oils by Ernest Guenther and Robert E. Kreiger
11. The Alkaloids : Chemistry & Physiology by RHF Manske (Volume)
12. Introduction to Molecular Phytochemistry by CHJ Wells. (Chapman and Hall)
13. Comparative Phytochemistry, edited by T. Swain.
14. Burger's medicinal chemistry edited by Alfred Burger.
15. Modern methods of plant analysis by Peach & M.V. Tracey, Vol. I to VII
16. Natural products – A Laboratory guide by Raphel Ikhan
17. The essential oils by Ernest Guenther and Robert E. Kreiger
18. The Alkaloids : Chemistry & Physiology by RHF Manske (Volume)
19. Chemistry of Marine Natural Products by Paul J Schewer
20. Marine Phamacognosy by Dean F. Martin & George Padilla

BACK

BOO-404 : Glycobiology **30 hours, 2 credits**

(Theory, 15 hours, 1 credit ; Practicals , 15 hours, 1 credit)

Objectives:- Glycobiology is " the study of the structure, biosynthesis, and biology of saccharides (sugar chains or glycans) that are widely distributed in nature."

1. Understand nomenclature, biosynthesis, structure, chemical synthesis, and functions of complex glycans

2. Understand applications in biomedical sciences, with relevance to basic research, biomedicine, and biotechnology.

Glycobiology: Principles and applications

I. Theory, 15 hours , One credit

1. General Principles:- Historical Background and Overview, Saccharide Structure and Nomenclature, Exploring the Biological Roles of Glycans (2)

2. **Biosynthesis, Metabolism, and Function:-** Monosaccharide Metabolism, N-Glycans, O-Glycans, Glycosphingolipids, Glycophospholipid Anchors, Proteoglycans and Glycosaminoglycans, Sialic Acids, overview of Glycosyltransferases, Degradation and Turnover of Glycans, Bacterial Polysaccharides (4)

3. Protein-Glycan interactions:-Discovery and Classification of Animal, Plant and fungal Lectins, Selectins, Galectins, Microbial Carbohydrate-binding Proteins, Plant Lectins, their Classification , Sequence, Toxicity, Isolation, Structure, Uses and functions; Fungal lectins, their structural diversity, biological functions, molecular characterization (4)

4. Methods and Applications:-Principles of Structural Analysis and Sequencing of Glycans, Chemical and Enzymatic Synthesis of Glycans, Natural and Synthetic Inhibitors of Glycosylation, Glycobiology in Biotechnology and Medicine (4)

5. Future perspectives:-Glycogenes, glycoscience and rational drug design (1)

Glycobiology: Principles and applications

II. Practicals, 15 hours, One credit

1. Simple tests to detect biological glycans (1)
2. Visualization of bacterial polysaccharide capsules (1)
3. Extraction of exocellular polysaccharides (EPS) from yeasts/fungi (2)
4. Quantitative Extraction of starch from plant storage organs (2)
5. Extraction of soluble lectins from plants and fungi (2)
6. Haemagglutination reaction/assays with plant and fungal lectins (2)
7. Affinity chromatography of lectins (partial purification) (2)
8. Application of IR-spectroscopy for characterizing polysaccharides (1)
9. Immobilization and use of amylase (2)

References:-

1. Essentials of glycobiology, Ajit Varki (ed), Cold Srping Harbour laboratory press, 2002
2. Techniques in glycobiology, R R Townsend & A T Hotchkiss, TF-CRC, 1997
3. Functional and Molecular Glycobiology, Brooks, S. A.Dwek, M. V.. Schumacher, U.PAP Edition , 2002
4. Molecular and Cellular Glycobiology, Fukuda, Minoru (Edt) / Hindsgaul, Ole (Edt) Paperback Edition , 2000
5. Essentials of Carbohydrate Chemistry and Biochemistry, Thisbe K. Lindhorst , Wiley, 2007
6. Glycopeptides and Glycoproteins - Synthesis, Structure, and Application
7. Edited by Valentin Wittmann , Springer, 2007
8. Synthesis and Characterization of Glycosides, Edited by Marco Brito-Arias Springer , 2007
9. Introduction to Glycobiology by Maureen E. Taylor and Kurt Drickamer, OUP, 2002
10. Lectins, Natan Sharon, Halina Lis, springer, 1999
11. Lectin-Microroganism interaction, R. Doyle, CRC, 1994
12. Ginsburg V., ed. 1972. Complex carbohydrates, part B. Methods Enzymol ., vol 28. Academic Press, San Diego, California.
13. Gottschalk A., ed. 1972. Glycoproteins: Their composition, structure and function. Elsevier, New York.
14. Ginsburg V., ed. 1978. Complex carbohydrates, part C . Methods Enzymol ., vol. 50. Academic Press, San Diego, California.
15. Lennarz W.J., ed. 1980. The biochemistry of glycoproteins and proteoglycans . Plenum Press, New York.
16. Ginsburg V. and Robbins P., eds. 1981. Biology of carbohydrates , vol. 1. Wiley, New York.
17. Ginsburg V., ed. 1982. Complex carbohydrates, part D. Methods Enzymol., vol. 83. Academic Press, San Diego, California.
18. Horowitz M. and Pigman W., eds. 1982. The glycoconjugates . Academic Press, New York.
19. Schauer R., ed. 1982. Sialic acids, chemistry, metabolism, and function . Springer-Verlag, New York.
20. Ivatt R.J., ed. 1984. The biology of glycoproteins . Plenum Press, New York.
21. Ginsburg V. and Robbins P., eds. 1985. Biology of carbohydrates , vol. 2. Wiley, New York.
22. Beeley J.G., ed. 1985. Glycoprotein and proteoglycan techniques . Elsevier, Amsterdam, The Netherlands.
23. Liener I.E., Sharon N., and Goldstein I.J., eds. 1986. The lectins: Properties, functions, and applications in biology and medicine . Academic Press, Orlando, Florida
24. Feizi T. 1989. Carbohydrate recognition in cellular function . Ciba Foundation Symposium, vol. 145. Wiley, New York.
25. Ginsburg V. and Robbins P., eds. 1991. Biology of carbohydrates, vol. 3. Wiley, New York.
26. Fukuda M., ed. 1992. Cell surface carbohydrates and cell development . CRC Press, Boca Raton, Florida.
27. Allen H.J. and Kisailus E.C., eds. 1992. Glycoconjugates: Composition, structure, and function . Dekker, New York.
28. Fukuda M., ed. 1992. Glycobiology: A practical approach . IRL Press, Oxford, United Kingdom.
29. Lennarz W.J. and Hart G.W., eds. 1994. Guide to techniques in glycobiology. Methods Enzymol., vol. 230. Academic Press, San Diego, California.
30. Bock K. and Clausen H., eds. 1994. Complex carbohydrates in drug research: Structural and functional aspects . Munksgaard, Copenhagen, Denmark.

31. Fukuda M. and Hindsgaul O., eds. 1994. Molecular glycobiology . Oxford University Press, New York.
32. Alavi A. and Axford J.S. 1995. Advances in experimental medicine and biology , vol. 376, Glycoimmunology . Plenum Press, New York.
33. Montreuil J., Vliegenthart J.F.G., and Schachter H., eds. 1995. Glycoproteins . Elsevier, New York.
34. Verbert A., ed. 1995. Methods on glycoconjugates: A laboratory manual. Harwood Academic Publishers, Switzerland.
35. Townsend R.R. and Hotchkiss A.T., eds. 1997. Techniques in glycobiology . Marcel Dekker, New York.
36. Iozzo R., ed. 2000. Proteoglycans: Structure, biology and molecular interactions. Marcel Dekker, Inc., New York.

BACK

BOO-405: REMOTE SENSING: TECHNIQUES AND APPLICATIONS (4 credits 3 + 1)

REMOTE SENSING Principles and basic concepts of Remote Sensing; Brief history of Remote Sensing; Active and Passive Remote Sensing; Aerial and Space Platforms – Balloons, Aircraft, and Satellites; Advantages of satellite remote sensing; Electro Magnetic Radiation (EMR) – Electromagnetic Spectrum: Transmittance, Absorptance, and Reflectance; effects of atmosphere, atmospheric windows; Visible, Infra Red (IR), Near IR, Middle IR, Thermal IR and Microwave. (8L)

SATELLITES AND SENSORS Satellites – Types; Sensors – Types, Active and Passive sensors; Satellite Sensors and Resolution; Optical Remote sensing; Multi Spectral Scanning and types of Scanners ; Advantages of multispectral scanners; Sensors in Landsat, SPOT, IRS series; Contemporary operational Satellites and their sensors; Microwave Remote Sensing; Side Looking Airborne Radar, Synthetic Aperture Radar; Hyperspectral imaging. (8 L)

DIGITAL IMAGE PROCESSING Remotely sensed digital images, characteristics, image resolution (Spectral resolution, Radiometric resolution, Spatial resolution and Temporal resolution); digital image pre-processing (Feature Extraction, Radiometric Corrections, Geometric Corrections, Atmospheric Correction), image enhancement, extraction of information and classification; elements of image interpretation; supervised and unsupervised classification. (10L)

GEOGRAPHIC INFORMATION SYSTEM. Principles of GIS; components of GIS – Hardware and Software; Data – Spatial and Non-Spatial; Maps – Types of Maps; Projection – Types of Projection; Data Input – Digitizer, Scanner; Raster and Vector data structures; Analysis using Raster and Vector data – Retrieval, Reclassification, Overlaying, Buffering, Output. Integration of GIS and Remote Sensing. (7L)

APPLICATIONS IN FORESTRY, AGRICULTURE AND ECOLOGY Principles of image interpretation in forestry and ecology; principles of multispectral sensing for vegetation mapping; spectral response of vegetation and factors affecting the spectral response; change detection and monitoring; Environmental Impact Assessment using remote sensing and GIS; quantitative estimation of biomass and other ecological parameters; estimation and measurement of tree and stand height, crown diameter, crown count, crown density etc.; Principles of Remote Sensing in Landuse /Land cover mapping. Estimation of global gross and net productivity from Earth Observing Systems. (12 L)

PRACTICALS:

1. Visual Interpretation of Black & White and False colour Multi Band Imagery. (1)
2. Transfer of Information from Imagery to Base Map. (1)

The following practicals are designed based on ILWIS package:

3. Exploration of single band and multiple band images including digital numbers. (1)
4. Contrast enhancement, calculation of histogram, linear stretching, histogram equalization. (2)
5. Spatial enhancement – applying filters for enhancement. (1)
6. Georeferencing of digital images – using corner points, using reference points and image to image registration. (2)
7. Linear, Non linear stretching. (1)
8. Rationing and Normalised Rationing and NDVI analysis. (2)
9. Image classification – Density slicing, interactive slicing. (1)
10. Supervised classification. (1)
11. Unsupervised classification. (1)
12. Presentation of results after analysis. (1)

TEXT BOOKS & REFERENCES

Anji Reddy, 2001. Remote Sensing and Geographical Information Systems, BS Publications.

Burrough, Peter A. and Rachael A. McDonnell, 1998. Principles of Geographical Information Systems. Oxford University Press.

Campbell, James B. 2002. Introduction to remote sensing. Guilford Press, New York.

Heywood, I. S. Cornelius and S. Carver, 2006. An Introduction to Geographical Information Systems. Prentice Hall.

Jensen, J.R. 2000. Remote Sensing of the Environment: An Earth Resource Perspective. Prentice Hall.

Lillesand, T.M., Ralph W Kiefer, Jonathan W Chipman, 2004. Remote Sensing and Image Interpretation. John Wiley & Sons

Rees W. G. 2001. Physical Principles Of Remote Sensing. Cambridge University Press.

Richards, John A., Jia, Xiuping, 2006. Remote Sensing Digital Image Analysis: An Introduction (4th ed.). Springer.

Sabnis, F. F. 1996. Remote Sensing: Principles and Interpretations. W H Freeman and Company 1996.

BACK

BOO-406: Plant Biochemistry: 4 credits (3+1)

1. Biomolecules – structure, function, isomerism & metabolism – Organization & Composition of Eukaryotic Cells; Integration & Control of Cellular functions, Structural components of Nucleic acids, higher order DNA structure, Amino acid composition of Proteins, higher levels of Protein organization, dynamic aspects of Protein structure & Protein stability, (12h)
2. Mechanism of Enzyme action – Introduction to Enzymes, How Enzymes work, Michaelis-Menten Model, Enzyme Kinetics as an approach to understanding mechanism, Enzymatic reactions, Regulatory Enzymes, (6h)
3. Metabolism, Pathways & Regulation – Carbohydrate metabolism – major metabolic pathways & their control, Lipid metabolism – utilization & storage of energy in lipid form, metabolic pathways of special lipids, Amino acid metabolism, Bioenergetics, Purine & Pyrimidine nucleotide metabolism, metabolic interrelationships (12h)
4. Expression & Transmission of Genetic information – Genetic control of Enzyme synthesis, Control of Gene expression, Gene expression in Prokaryotes & Eukaryotes, Response to environmental changes – Sensory systems (9h)
5. Signal Transduction pathways – Cell surface receptors, G proteins coupled secondary messenger. (6h)

Practicals: (any 15 practicals)

- Extraction, purification and estimation of proteins 3 P
- Amino acid composition of proteins 2 P
- Oxidative damage to proteins 1 P
- Separation of protein by PAGE (preparation of gradient gel, preparation of protein sample, running, development and documentation of gel) 3 P
- Extraction, purification of lipids 1 P
- Separation of glycol-phospho and neutral lipids (chromatographically) 2 P
- Quantitative estimation of phospho and glycolipids (spectrophotometrically) 2 P
- Determination of fatty acids (GC) 2 P
- Activity of antioxidant enzymes (SOD using epinephrine method) 1 P
- Preparation of artificial membrane (liposomes) and size measurements 1 P
- Immobilization of whole cell and isolated organelle 1 P
- Extraction of sugar (soluble and non-soluble) and Estimation of sugar (total, reduced, non reduced)

BACK

DISSERTATION

Total: 8 Credits (This is in lieu of optional courses equivalent to 8 credits)

Duration: III & IV Semester

Should be carried out under the guidance of a Teacher.

BACK