Goa University

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

Syllabus of M.Sc. (Botany) Programme
To be implemented from Academic Year 2015-16

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. programme 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 12 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
BOC-101	Algae, Bryophytes, Pteridophytes, Gymnosperms	3-1-0	4
BOL-101	Lab in Algae, Bryophytes, Pteridophytes, Gymnosperms	0-0-1	1
BOC-102	Plant Microbiology and Pathology	3-1-0	4
BOL-102	Lab in Plant Microbiology and Pathology	0-0-1	1
BOC-103	Taxonomic methods and classification of Angiosperms	3-1-0	4
BOL-103	Lab in Taxonomic methods and classification of Angiosperms.	0-0-1	1
BOC-201	Internal Morphology and Developmental Biology: Angiosperms.	3-1-0	4
BOL-201	Lab in Internal Morphology and Developmental Biology: Angiosperms	0-0-1	1
BOC-203	Advanced Ecology	3-1-0	4
BOL-203	Lab in Advanced Ecology	0-0-1	1
BOC-204	Fungal Biodiversity, Bioprospecting and Biotechnology	3-1-0	4
BOL-204	Lab in Fungal Biodiversity, Bioprospecting and Biotechnology	0-0-1	1
BOC-205	Plant Physiology	3-1-0	4
BOL-205	Lab in Plant Physiology	0-0-1	1
BOC-301	Plant Molecular Biology	3-1-0	4
BOL-301	Lab in Plant Molecular Biology	0-0-1	1
BOC-302	Plant Genetic Engineering	3-1-0	4
BOL-302	Lab in Plant Genetic Engineering	0-0-1	1
BOC-401	Cytogenetics and Plant Breeding	3-1-0	4
BOL-401	Lab in Plant Genetic Engineering	0-0-1	1

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

Course Number	Course Title	L-T-P (hours/ week)	Credits
BOO-101	Techniques and Instrumentation in Botany	3-0-1	4
BOO-102	Bioinformatics and Chemoinformatics	3-0-1	4
BOO-103	Oenology	1-0-1	2
BOO-104	Mine Wasteland management	1-0-0	1
BOO-105	Practical course in Plant identification	0-0-1	1
BOO-201	Plant-Animal Interactions	4-0-0	4
BOO-202	Ethnobotany	2-0-0	2
BOO-203	Mycological Techniques	3-0-1	4
BOO-301	Applied Phycology:Utilization and Management	2-0-0	2
BOO-302	Plant Biotechnology	3-0-1	4
BOO-303	Mycorrhizal Biotechnology	2-0-1	3
BOO-304	Plant Histochemistry	2-0-1	3
BOO-305	Horticulture, Landscaping and Gardening	2-0-1	3
BOL-305	Lab in Horticulture, Landscaping and Gardening	0-0-1	1
BOO-401	Fungal Chemistry and Mycoremediation	1-0-1	2
BOO-402	Photosynthesis and Crop Productivity	2-0-0	2
BOO-403	Phytochemistry	1-0-1	2
BOO-404	Glycobiology	1-0-1	2
BOO-405	Remote sensing : Techniques and applications	3-0-1	4
BOO-406	Plant Biochemistry	3-0-1	4
BOO-407	Bioentreprenurship and innovation	1-0-1	2
BOO-408	Mushroom biotechnology	1-0-1	2
BOO-409	Seed science and technology	3-1-0	4
BOO-410	Marine phytoplanktons	1-0-0	1
BOO-411	Ecotourism	2-0-2	4
BOO-412	Advances in Mycology: Taxonomy, Biology and Application of Fungi	2-0-1	3
BOO-DIS	**Dissertation**	0-0-12	12

COMPULSORY COURSES

BOC-101: Algae, Bryophyta, Pteridophyta and Gymnosperms – 4 Credits
(3 Credits Theory: 45 hours + 1 Credit Tutorial: 15 hours)

Objectives: To study general characteristics, classification, trends in classification, phylogeny and inter-relationships of Algae, Bryophyta, Pteridophyta and Gymnosperms.

Pre-requisite: Knowledge of the subject at UG level.

Syllabus:

Algae:

1. General Introduction to algae; Classification of Algae; Recent trends in the classification of algae. **(2L)**
2. General account of morphology, anatomy, reproduction, life histories, classification, Phylogeny and inter-relationships, ecological and economic importance of the following: Chlorophyta, Charophyta, Euglenophyta, Phaeophyta, Cryptophyta, Chrysophyta, Pyrrhophyta and Rhodophyta. **(8L)**
3. Brief account of Cyanophyta (Cyanobacteria). **(1L)**

Bryophyta:

1. Introduction to Bryophyta; General characteristics, classification, ecological and economic importance of Bryophytes. **(1L)**
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. **(9L)**

Pteridophyta:

1. General characters and classification of Pteridophytes, ecological and economic importance of Pteridophyta.**(1L)**
2. Comparative account of Psilotales Lycopodiales, Selaginallales, Isoetales, Equisetales, Ophioglossales, Marattiales, Osmundales, Filicales, Marsileales and Salviniales. **(6L)**
3. Apospory and Apogamy, Heterospory. **(1L)**
4. Soral evolution, Fossil Pteridophytes. **(2L)**

Gymnosperms:

1. General characters and classification of Gymnosperms. **(1L)**
2. Comparative account of morphology, anatomy, phylogeny and interrelationship of Pro-gymnospermopsida, Gymnospermopsida and Gnetopsida. **(10L)**
3. Fossil Gymnosperms. **(1L)**

Reference Books:

Agashe, S. N. (1995). Paleobotany, Oxford and IBH Publ. Co. Pvt. Ltd, New Delhi.

Arnold, A. C. (2005). An Introduction to Paleobotany, Agrobios (India), Jodhpur.

Bhatnagar S. P. and Moitra A. (1996). Gymnosperms. New Age International, New Delhi.

Biswas C. and Johri B. M. (1997). Gymnosperms. Narosa Publishers, NewDelhi.

Bold H.C. and Wynne M. J. (1978). Introduction to the algae; Structure and reproduction. Prentice Hall, Englewood cliffs, New Jersey.

Cavers, F. (1976). The inter relationships of the bryophyte. S.R. Technic, **Ashok Rajpath**, Patna.

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

Chopra, R. N., and Kumar P. K. (1988). Biology of Bryophytes. John Wiley and Sons, New York, NY.

Desikachary, T.V. (1959). Cyanophyta ICAR, New Delhi

Hoek, C. van den, Mann, D. G. and Jahns, H. M. (1995). Algae: An introduction to Phycology, Cambridge University Press, UK.

Kashyap, Shiv Ram (1929). Liverworts Of The Western Himalayas And The Panjab Plain Part 1 Chronica Botanica New Delhi.

Kashyap, Shiv Ram, (1932). Liverworts of the western Himalayas and the panjab plain (illusterated): Part 2. The Chronica Boanica New Delhi.

Parihar, N.S. (1976). Biology and morphology of the Pteidophytes Central Book Depot.

Parihar, N. S. (1980). Bryophytes: An introduction to Embryophyta Vol I Bryophyta central Book Depot.

Prem Puri (1981). Bryophytes: Morphology, Growth and Differentiation, Atmaram and Sons, New Delhi.

BOL-101: Lab in Algae, Bryophyta, Pteridophyta and Gymnosperms –1 Credit (1 Credit Practical: 15 hours)

Objectives: To introduce and expose the students to skills required in field and lab based on theory.

1. Collection and preservation techniques for planktonic, epiphytic, and benthic algae. **(1P)**
2. Study of vegetative and reproductive features of important algal groups with the available representatives of Chlorophyta, Charophyta, Euglenophyta, Chrysophyta, Cryprtophyta, Pyrrhophyta, Phaeophyta and Rhodophyta. **(5P)**
3. Study of vegetative and reproductive features of important bryophytes groups with the available representatives Hepaticae, Anthocerotae and Musci. **(3P)**
4. 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)**
5. Vegetative and reproductive features of Gymnospermopsida and Gnetopsida with available representatives. **(3P)**

BOC-102: Plant Microbiology and Pathology – 4 Credits (3 Credits Theory: 45 hours + 1 Credit Tutorial: 15 hours)

Objectives: The aim of the course is, for students of botany, to understand the diversity and biology of fungi; microbial world, plant diseases and fundamental concepts needed to manage crop diseases. The paper covers mycology, microbiology and principles of plant pathology, with particular emphasis on identification of diseases and disease causative agents. Major scope is on understanding the fungi, microbiology, plant protection, and cultural, chemical and biological control of diseases. In the plant pathology component, the course will also deal with host-pathogen physiology, genetics, taxonomy of disease causing organisms, chemistry of fungicidal actions, etc. The students will understand fungi, microbes, the nature of plant diseases and how control practices work.

Pre-requisite: Knowledge of basic microbiology-bacteria, viruses, fungi and plant pathogens at UG level.

Syllabus:

1. **General Introduction:** Plant microbe interactions in health and diseases and the changing picture due to climate change. **(2L)**
2. **Plant Virology:** Origin of viruses, introduction to molecular virology, Virology on Internet - viral databases and their use for understanding viral phylogeny, Viral genomics and proteomics; Viral nucleic acids, enzymes and proteins; classification and nomenclature of Viruses with special stress on plant viruses; modern techniques to study the viruses; Morphology, chemical composition, ultrastructure, replication; The virus cryptogram; Transmission of Plant Viruses; Virus-Vector relationship; Control of Plant Viruses; present knowledge of Viroids. Practical applications of viruses in nanobiotechnology; the enigmatic prions. **(8L)**
3. **Plant Bacterial Interactions and Mycoplasma:** Evolutionary aspects of plant microbe interaction; Species of bacteria associated with plants in health and disease; bacterial endophytes; phylloplane and rhizhosphere microbiology; role of bacteria in biogeochemical cycling; Present picture of phylogeny and systematics of bacteria; techniques used to study plant-microbe interactions; Agriculturally beneficial bacteria; Economic importance in relation to biological N-fixation and production of antibiotics and enzymes, importance of Actinobacteria and actinorrhiza. Present knowledge of biology and role of Mycoplasma and L-forms; techniques used in understanding plant-bacteria interaction and agriculturally important bacteria. **(8L)**
4. **Mycological Dimensions of Plants:** Plants and fungi interaction through the window of evolution; present knowledge of fungal biodiversity, phylogeny and classification; fungal plant ecology and fungal endophytes; general biology, forms, structure and functions of Fungi; physiological aspects and nutritional modes of fungi; fungal genetics at classical and molecular level; the fungal holomorph; asexual and sexual reproduction; Structural, functional and ecological specialization of fungal mycelia and spores; Modern fungal systematics, Morphology and molecular-based taxonomy; fungi in tropical habitats in relation to the plants.

5. **Study of different groups of fungi with suitable native examples:** Slime moulds, Chytridiomycota; Ooomycota; Glomeromycota; Zygomycota; Ascomycota and Basidiomycota; Straminopile fungi.
6. **Economic and biotechnological dimension of 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; use of fungi for green chemistry and nanobiotechnological applications. **(12L)**
7. **Tropical Plant Pathology:** Diseases of plants in the tropics and their systematic studies using modern techniques. Changing picture of plant diseases due to habitat modifications and climate change. A brief history of plant pathology in India. Major plant disease epidemics recorded in history and their significance. 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; Susceptibility 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, smut, grassy shoot disease), groundnut (tikka), cotton (wilt), coconut (leaf blight, wilt, yellowing), banana (leaf spot, bunchytop), mango (powdery mildew, sooty mould). Post-harvest and market pathology; Seed certification. **(15L)**

Reference Books:

Atlas, M. and Bartha, R. (2000). Microbial Ecology, Longmann, New York.

Black, J. G. (1999). Microbiology –Principles and Explorations, Prentice Hall, London.

Brock, T. D. (1996). Biology of microorganisms Prentice Hall, London.

Casida, L. E. (1997). Industrial microbiology. New Age Publishers, New Delhi.

Dubey, R. C. and Maheswari, D. K. (2010). A Text book of Microbiology, S.Chand & Company, New Delhi.

Gerald Karp (2008). Cell and Molecular biology-concepts and experiments. John Wiley & Sons, New York.

Kumar, H. D. and Swati Kumar (1999). Modern concepts of Microbiology, Vikas Publishing House, New Delhi.

Harvey L., Arnold B., Zipursky S. L., Matsudaira P., Baltimore D. and Darnell, J. (2008). Molecular Cell Biology 6th ed. W. H. Freeman & Co. New York.

Pelezar, M. J., Chan, E. C. S and Kreig, N. R. (1993). Microbiology-concepts and Applications. McGraw Hill, Inc. New York.

Powar, C. B. and Daginawala, H. F. (1982). General Microbiology Vol.II. Himalaya Publishers, Bombay.

Rao, A. S. (2001). Introduction to Microbiology. Prentice Hall of India, New Delhi.

Ainsworth, G. C., Sparrow, F. K. and Sussman, A. S. (1973). The Fungi. Academic Press, New York.
Alexopoulose, C. J., Mims, C. W., Blackwell, M. (1996). Introductory Mycology. John Wiley & Sons, New York.
Bessy, E. A. (1979). Morphology and Taxonomy of Fungi.Vikas Publishing House, New Delhi.
Burnett, J. H. (1968).Fundamentals of Mycology. Edward Arnold Ltd. London.
Chopra, G. L. (1998). A text book of Fungi. S. Nagin & Co. Meerut.
Dube, H.C. (1996). An Introduction to Fungi. Vikas Publish.House, New Delhi.
Elizabeth Moore-Landeeker (1996).Fundamentals of Fungi. Prentice Hall, New Jersey.
Hale, M. E. (1983).Biology of Lichens. Edward Arnold, London.
Hudson, H. J. (1986). Fungal Biology. Edward Arnold, London.
Mehrothra, R. S. and Aneja, K. R. (1990). An Introduction to Mycology. Wiley Eastern Ltd. New Delhi.
Sharma, O. P. (2007).Text book of Fungi. Tata McGraw Hill, Publishing Co. Ltd. New Delhi.
Sharma, P. D. (2004).The Fungi for University students. Rastogi Publications, Meerut.
Srivastava, J. P. (1998). Introduction to Fungi. Central Book Depot, Allahabad.
Sumbali, G. (2005). The Fungi. Narosa Publishing House, New Delhi.
Agrios, G. N. (1997). Plant Pathology. Academic Press, New Delhi.
Bilgrami, K. S. and Dube, H. C. (1990).A text book of Modern Plant Pathology. Vikas Publishing House, New Delhi.
Butler, E. J. and Jones, S. G. (1949).Plant Pathology. Mc Millan, London.
Chatterjee, P. B. (1997). Plant Protection Techniques. Bharati Bhavan, Patna.
Chattopadhayay, S. B. (1991).Principles and Procedures of Plant Protection. Oxford & IBH, New Delhi.
Manners, J. G. (1982). Principles of Plant Pathology. Cambridge University Press, London.
Marshall, H. (1999). Diseases of Plants. Anmol Publications Pvt. Ltd. New Delhi.
Mehrotra, R. S. (2000). Plant Pathology. Tata McGraw Hill, Publishing Co. Ltd. New Delhi.
Mundkur, B. B. (1982). Text Book of Plant Diseases. Macmillan India Ltd., New Delhi.
Pathak, V. N., Khatri, N. K. and Pathak, M. (1996). Fundamentals of Plant Pathology. Agrobotanical Publishers (India), Bikaner.
Rangaswamy, G. and Mahadevan, A. (2002). Diseases of Crop Plants in India. Prentice Hall of India, New Delhi.
Sharma, P. D. (2005). Plant Pathology. Narosa Publishing House, New Delhi.
Singh, R. S. (2000). Introduction to the Principles of Plant Pathology. Oxford IBH, New Delhi.

BOL-102: Lab in Plant Microbiology and Pathology –1 Credit (1 Credit Practical: 15 sessions)

Objectives: To impart requisite skills in plant microbiology and pathology with emphasis on tropical strains.

1. Microbial ecology in relation to the plants-Introduction to field and lab techniques to study plant-microbe interactions and isolation and maintenance of pure cultures using common microbiological media.
2. Phylloplane and rhizosphere microflora- visualization and isolation.
3. Use of Microscopy in studying microbes in detail - preparation of unstained and stained specimens of eubacteria, actinobacteria, yeasts, fungi; gram character of bacteria.
4. Photomicrography and digital image analysis of representative pure cultures and interpretation of results.
5. SEM study of plant viruses using electron dense stains.
6. Studying Phylogeny of plant viruses using bioinformatics tools.
7. Study of root nodulation, symbiosome, Nitrogen fixing *Rhizobium*, leghemoglobin and Quorum Sensing in bacterial population.
8. Methods of isolation and culturing of fungi: colony characters; microscopic observations; morphology of hyphae and spores; reproductive structures of different genera of fungi.
9. Study of fungal physiology in pure colonies – characterization of fungal colonies.
10. Microfluidics in mycology- fabrication and application of microfluidics devices to fungal cultures for real time visualization of fungal metabolic activities.
11. Introduction to mycological databases and mycosystematics on Internet; introduction to Mycobioinformatics- tools and techniques (exercise to construct fungal phylogenetic tree to be given).
12. Observation of different fungal substrates using sterile moist chamber incubation (e.g. herbivore dung; decomposing leaf-litter); Observations on ecological succession of fungi; Terrestrial, marine and freshwater fungi.
13. Particle-plating, endophyte isolation and serial dilution techniques (e.g. soil, dung and leaf litter).
14. Collection of infected specimens in the field; Observation of symptoms; Laboratory studies; Hand sections and tease mounts.
15. Study of as many as possible viral, bacterial and fungal diseases of crop plants (cereal, vegetable, fruit, and plantations) from surrounding habitats in Goa.
16. Submission of 10 dried herbarium specimens of infected plant materials [fungal (4) + bacterial (3) + viral (3)] collected from nearby habitats.
17. A mini field project to study crop diseases from field and market specimens.

BOC 103: Taxonomic Methods and Classification of Angiosperms – (4 Credits)
(Theory: 45 hours + Tutorial: 15 hours)

Objectives: Taxonomy is fundamental to the rest of the studies in biology and at the same time it takes inputs from other branches. The ultimate aim of taxonomy is to understand the evolution at work. Angiosperms being the dominant as well as most evolved plant group the source of characters for taxonomy are also varied. It is also being practiced at various levels, from morphology to phylogenomics. This course aims to give comprehensive understanding in angiosperm taxonomy as well as its practice. At the end of the course students would have learnt various aspects of taxonomy including methods, principles, practices, application of nomenclature and the modern classification.

Pre-requisite: Knowledge of the subject at UG level.

Syllabus

1. **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. **(6L)**
2. **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. **(6L)**
3. **International Code of Plant Nomenclature:** Purpose, Principles, and overall knowledge of Articles pertaining to typification, publication, priority, author citation and their application**. (8L)**
4. **Taxonomic characters other than morphology:** Characters from anatomy, embryology, palynology, chromosomes, seconday metabolites, proteins, nucleic acids in taxonomy. **(10L)**
5. **Numerical methods in taxonomy:** Phenetics, Principal Component Analysis, Discriminant Analyses. **(5L)**
6. **Cladistics:** Introduction – advantages and problems; classical taxonomy as base for molecular systematics; systematics and phylogenetics 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. Sequences – finding homologous sequences and alignment; local vs global alignment; pairwaise and multiple sequence alignment. Tree construction – algorithmic (UPGMA and Neighbour Joining) and tree-searching (Parsimony, Maximum Liklihood and Bayesian). Phylogenomics as the modern trend in plant taxonomy. **(9L)**
7. **Phytogeography:** Basic terminologies and their understanding; endemism – types and causes; vicariance; phytogeography and applications; floristic regions of the world (Takhtajan). **(6L)**
8. **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)))). **(10L)**

Reference Books:

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. and V.M. Heywood. 1963. Principles of Angiosperm Taxonomy. Oliver & Boyd, Edinburgh.

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

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

Jain, S.K. and 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. and 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 and 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 and 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 and C.R. Bell. 1974. Vascular Plant Systematics, Harper & Row, New York.

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

Salemi, M. and 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 and Michael J. Donoghue, 2007. Plant Systematics: A Phylogenetic Approach, Third Edition.Sinauer Associates, Inc., Publishers, Sunderland, USA.

BOL-103: Lab in Taxonomic Methods and Classification of Angiosperms – (1 Credit)
(Practical: 15 sessions)

Objectives: To learn plant taxonomy through dissection of flowers, use of Floras and field study and develop skills to handle any plant identification and floristic work independently.

1. Morphological terms using local specimens. **(2P)**
2. Writing of technical descriptions. **(1P)**
3. Construction of keys. **(1P)**
4. Botancial illustrations (line drawing) following basic rules regarding proportion, scientific accuracy, scale, numbering and legend. **(1P)**
5. Identification of local species using Floras, keys and campus field trips. **(4P)**
6. Identification of 25 families using diagnostic characters; diagnostic characters to be illustrated. **(5P)**
7. Construction of phylogentic tree based on gene sequences available at NCBI database (each student may be given different gene sequences/taxa). **(1P)**

Reference Books:

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

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

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

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

Utteridge, T. and G. Bramley. 2014. Tropical Plant Families Identification Handbook.Kew Publishing.

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

BOC-201: Internal Morphology and Developmental Biology: Angiosperms – 4 Credits (3 Credits Theory: 45 hours + 1 Credit Tutorial: 15 hours)

Objectives: The paper provides deeper understanding of various anatomical structures and their functions, various embryological process, applied aspects of embryology, pollen biology and pollen biotechnology of flowering plants.

Pre-requisite: Knowledge of the subject at UG level.

Syllabus:

Internal Morphology

1. Origin, growth, differentiation and ultra-structure of cells and tissues; fine structure of plasmodesmata, microtubules, microfibrils. **(2L)**
2. **Cell Walls:** Genesis and ultra-structure of cell walls, pits, cell-wall polymers, incrustation and adcrustation of cell walls; symplasm and apoplasm. **(2L)**
3. **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. **(5L)**
4. Vascular cambium vs cork cambium, factors controlling their activity; lenticels; abscission; wound healing. **(2L)**
5. Ontogeny, phylogeny, evolution, ultra-structure and function of primary and secondary xylem; wood anatomy; bio-deterioration of wood and its prevention. **(6L)**
6. Ontogeny, phylogeny, evolution, ultra-structure and function of primary and secondary phloem. **(2L)**
7. 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. **(4L)**
8. **Nodal anatomy:** nodal types, phylogenetic and evolutionary considerations. **(2L)**
9. Anatomy of monocotyledonous and dicotyledonous seeds and fruits - their ontogeny structure and functions. **(4L)**

Embryology

1. **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. **(3L)**
2. **Megasporogenesis and formation of embryo sac:** Ovule differentiation and development, megasporogenesis, organization of embryo sac, types of embryo sac, gene function during megagametogenesis. **(3L)**
3. **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. **(6L)**
4. **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. **(6L)**

Palynology

1. **Pollen Biology:** Pollen wall features, development and evolution of pollen types, palynology and taxonomy. **(5L)**
2. **Aeropalynology:** Methods of aerospora survey and analysis; pollen allergy and pollen calendars. **(2L)**
3. **Mellittopalynology:** Honey bee and pollen loads; role of apiaries in crop production. **(2L)**
4. **Palaeopalynology:** Study of fossil pollens and spores and their significance in paleobotany and coal and oil explorations. **(2L)**
5. Pollen biotechnology for crop production and improvement. **(2L)**

Reference Books

Batygina T. B. 2009. Embryology of Flowering Plants Terminology and Concepts, Volume 3, Reproductive Systems, Science Publishers, USA.

Raghavan V. 2000. Developmental Biology of Flowering Plants, Springer-Verlag, New York.

Bhojwani S. S. and Bhatnagar S. P. 1984. Embryology of Angiosperms, Vikas Publishing House, New Delhi.

Johri B.M. 1984. Comparative Embryology of Angiosperms, Ind. Nat. Sci. Acad., New Delhi.

Maheshwari P. 1985. An Introduction to Embryology of Angiosperms, Tata McGraw Hill, New Delhi.

Fahn. A. 1990. Plant Anatomy, 4th Edition, Pergamon press, New York, Oxford.

Eames A. J. and Mac Daniels L. H. 1947. Introduction to Plant anatomy, McGraw Hill, New York.

Esau K. 1985. Plant anatomy, 2nd Edition, Wiley Eastern Limited, New Delhi.

Metcalf C. R. and Chalk L. 1950. Anatomy of Dicots Vol. I & II, London Press, Oxford.

Romberger J. A., Hejnowicz Z. and Hill J. F. 1993. Plant Structure: Function and Development, Springer-Verlag.

Endtman G. 1952. Pollen Morphology and Plant Taxonomy: Angiosperms, Almquist and Wiksell. Stockholm.

Erdtman G. 1966. Pollen Morphology and Plant Taxonomy: Angiosperms, Hafner Publishing Co., New York.

Nair P.K.K. Essentials of Palynology, Asha Publishing House, New York.

Nair P.K.K. 1966. Pollen morphology of angiosperms, Periodical Expert Book Agency, New Delhi.

Nair P.K.K. 1970. Pollen Morphology of Angiosperms A Historical and Phylogenetic Study, Scholar Publishing House, Lucknow.

Shivanna, K. R. and Sawhney V. K. 1997. Pollen Biotechnology for Crop Production and Improvement, Cambridge University press. U.K.

Lyndon R. F. 1990. Plant Development, the Cellular Basis. Cambridge University Press, UK.

Hesse M. and Ehrendorfer F. 1990. Morphology, Development and Systematic Relevance of Pollen and Spores, Springer-Verlag, New York.

BOL-201: Lab in Internal Morphology and Developmental Biology: Angiosperm –1 Credit (Credit Practical: 15 Sessions)

Objectives: To learn plant anatomy, embryology and palynology through sectioning and staining of various vegetative and reproductive parts of plants. Development of skills such as isolation of embryo and endosperm from early stages of seed development. Also to study various ornamentation patterns in pollen grains from flower and honey samples.

1. Comparative anatomy of monocotyledon and dicotyledon root, stem and leaf. **(1P)**
2. Anatomical basis of identification C_3 & C_4 sub types in grasses. **(1P)**
3. Phytoliths of grasses and their potential use in identification. **(1P)**
4. Anatomy of lenticels and periderm in plants. **(1P)**
5. Anatomy of monocotyledonous and dicotyledonous seeds. **(1P)**
6. Study of different types of stomata and trichomes. **(1P)**
7. Maceration of wood to study xylem components. **(2P)**
8. Study of microsporangium and microsporogenesis. **(1P)**
9. Study of megasporangium and embryo sac development. **(1P)**
10. Study of types of endosperm and its modifications. **(1P)**
11. Study of development of embryo in dicot and monocot. **(1P)**
12. Study of different ornamentation patterns in pollen grains by acetolysis. **(2P)**
13. Analysis of honey samples to identify uni-floral or multi-floral honey. **(2P)**

Reference Books

Batygina T. B. 2009. Embryology of Flowering Plants Terminology and Concepts, Volume 3, Reproductive Systems, Science Publishers, USA.

Raghavan V. 2000. Developmental Biology of Flowering Plants, Springer-Verlag, New York.

Bhojwani S. S. and Bhatnagar S. P. 1984. Embryology of Angiosperms, Vikas Publishing House, New Delhi.

Johri B.M. 1984. Comparative Embryology of Angiosperms, Ind. Nat. Sci. Acad., New Delhi.

Maheshwari P. 1985. An Introduction to Embryology of Angiosperms, Tata McGraw Hill, New Delhi.

Fahn. A. 1990. Plant Anatomy, 4th Edition, Pergamon press, New York, Oxford.

Eames A. J. and Mac Daniels L. H. 1947. Introduction to Plant anatomy, McGraw Hill, New York.

Esau K. 1985. Plant anatomy, 2nd Edition, Wiley Eastern Limited, New Delhi.

Metcalf C. R. and Chalk L. 1950. Anatomy of Dicots Vol. I & II, London Press, Oxford.

Romberger J. A., Hejnowicz Z. and Hill J. F. 1993. Plant Structure: Function and Development, Springer-Verlag.

Endtman G. 1952. Pollen Morphology and Plant Taxonomy: Angiosperms, Almquist and Wiksell. Stockholm.

Erdtman G. 1966. Pollen Morphology and Plant Taxonomy: Angiosperms, Hafner Publishing Co., New York.

BOC-203: Advanced Ecology – 4 Credits (3 Credits Theory: 45 hours + 1 Credit Tutorial: 15 hours)

Objectives: This course discusses modules from ecology of climate change, carbon trading to tropical soil ecology, chemical ecology, industrial and urban ecology, landscape ecology, environmental impact assessment and encourages the students to use online tools, software, GIS, satellite images, toposheets besides interesting field and laboratory exercizes. The students are exposed to state of the art developments in ecology and current issues affecting the planet.

Pre-requisite: Knowledge of ecology at U.G. Level.

Syllabus

1. **Ecology of climate change and development (ECCD):** Climate change-the current picture after COP-20; Importance of findings of AR-5 of IPCC; 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; The Indian response to climate change, 4 X 4 report of MOEF; Adapting to climate change in 21st Century, efforts for mitigation, CDM, Carbon trade, Carbon credits. **(7L)**
2. **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, 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. **(6L)**
3. **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 immobilization of nutrients; tropical Forest soils; Earthworms and composting, soil erosion and soil fertility management. **(5L)**
4. **Landscape and plant 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, Principles of plant ecology, plant communities, ecotones, edge effect; 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. **(9L)**

5. **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. **(7L)**
6. **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. **(6L)**
7. **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; Study of EIA manuals. **(5L)**

Reference 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 and 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.

<u>BOL-203: Lab in Advanced Ecology</u> – 1 Credit (1 Credit Practical: 15 sessions)

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. Study of ecotones and edges in natural ecosystems.
7. Application of quadrat studies in landscape science.
8. Analysis of soil humic matter, Detection of soil enzymes using chromogenic substrates.
9. Isolation of soil microbiota and assessment of their ecological role.
10. Landscape analysis and modeling using software tools.
11. Landscape analysis using satellite imagery data.
12. Cataloguing urban land use and biodiversity using maps and field data.
13. Conceptualizing a model urban ecosystem using design tools.
14. Flowcharting an industrial ecosystem.
15. Evaluating local ecosystem services using standard equations (Costanza, 1997).
16. Conceptualizing rainwater harvesting system for an industrial estate.
17. Performing Rapid EIA using Leopold interaction matrix (different projects).
18. Software for EIA –solid waste management.
19. Performing rapid biological impact analysis.

BOC-204: Fungal Biodiversity, Bioprospecting and Biotechnology – – 4 Credits (3 Credits Theory: 45 hours + 1 Credit Tutorial: 15 hours)

Objectives: To introduce students to interesting and exciting world of biodiversity of fungi in different ecosystems and habitats, their role in ecosystem functioning, their chemical creativity useful in biotechnology and economy based on industrially important strains.

Pre-requisite: Knowledge of fungi and fungal biotechnology at UG Level.

Syllabus:

1. **Fungal biodiversity:** 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.**(15L)**
2. **Fungal bioprospecting:** 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. **(10L)**
3. **Fungal biotechnology:** 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. **(20L)**

Reference Books

Nair, L. N. (2007). Topics in Mycology and Pathology, New Central Book agency, Kolkata.

Oliver R. P. and Michael Schweizer (1999). Molecular Fungal Biology, CUP.

Berry D. R. (1988). Physiology of industrial Fungi, Blackwell Scientific Publishers.

Zhingiang Ann (2005). Handbook of Industrial Mycology, CRC Press.

Annonymous (2006). Handbook of the Convention on Biological Diversity, CBD secretariat, earthscan.

Satyanarayana T. and Johri B.N. (2005). Microbial diversity, Current Perspectives and Potential Applications , IK international .

Gregory Michael Mueller, Gerald F. Bills and Mercedes S. Foster (2004). Biodiversity of fungi: inventory and monitoring methods, Academic Press.

Arora Dilip K. (2004). Fungal biotechnology in agricultural, food, and environmental applications, CRC Press.

Jan S. Tkacz and Lene Lange (2004). Advances in fungal biotechnology for Industry, Agriculture, and Medicine, Springer.

Alan T.Bull (2004). Microbial Diversity and Bioprospecting, ASM Press.

Robson, G. D., Pieter van West and Geoffrey Gadd (Eds.) (2007). Exploitation of Fungi (British Mycological Society Symposia), CUP, 350 pp.

BOL-204: Lab in Fungal Biodiversity, Bioprospecting and Biotechnology – 1 Credit (1 Credit Practical: 15 sessions)

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.

BOC-205: Plant Physiology – 4 Credits (3 Credits Theory: 45 hours + 1 Credit Tutorial: 15 hours)

Objectives: This course teaches processes of various plant functions such as plant water relationship, mineral nutrition and assimilation (nitrogen, sulphur and other inorganic nutrients), photosynthesis with emphasis on mechanism of abiotic stresses at physiological and molecular level with reference to crop productivity. Lipids and carbohydrate metabolism, enzymes and bioenergetics of all four type of reactions. Plant growth and development (signal transduction). The course also briefly covers secondary plant metabolites. The course also emphasizes on molecular mechanism of signal transduction due to environmental or stress factors and physiological response. Students should have, as a prerequisite for the course, a good understanding of various physiological processes taking place in plants.

Pre-requisite: Knowledge of the subject at UG level.

Syllabus

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. **(2L)**
2. Water relation of plants, unique physico chemical properties of water; bulk movement of water, aquaporins, stomatal regulation of transpiration, anti transpirants. **(2L)**
3. Inorganic nutrition, macro and micro nutrients, deficiency symptoms, hydroponic studies; mineral absorption and translocation and assimilation; Nernst equation and Donnan's equilibrium. **(2L)**
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. **(3L)**
5. **Photosynthesis:** Importance of photosynthesis, Photosynthesis and environment. 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). **(6L)**
6. **Dark reaction:** Carbon dioxide fixation in C3, C4 and CAM plants regulation of PCR cycle; photorespiration and its regulation, environmental factors affecting photosynthesis. **(3L)**
7. **Respiration:** Aerobic and anaerobic respiration; cyanide independent respiration; fermentation; cytochrome system; carbohydrate and lipid metabolism; high energy compounds and factors affecting respiration. **(4L)**
8. **Bioenergetics:** Chemiosmotic hypothesis and energy transduction; energy transducing organelles mechanism of ATP synthesis, quantitative bioenergetics. **(2L)**
9. **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. **(2L)**

10. Growth and development: Phytochromes and light control, regulatory mechanism; role of phytochrome in phototropism; physiology of flowering and fruiting. **(4L)**

11. 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. **(5L)**

12. 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. **(2L)**

13. Stress Physiology: Abiotic and biotic stresses, morphological and cellular adaptation; molecular mechanism of stress tolerance and protection. **(3L)**

14. Seed dormancy and germination, senescence, circadian rhythms in plants (exogenous factors and molecular mechanism). **(2L)**

15. Secondary plant metabolities (steroids, alkaloids, tannins, phenols) in higher plants and lower organisms. General and specific biosynthetic pathways, Application, Allelopathic substances. **(3L)**

Reference Books

Nair, L. N. (2007). Topics in Mycology and Pathology, New Central Book agency, Kolkata.

Taiz L. and Zeiger E. Plant Physiology. Panima, New Delhi

Henry R.J. Plant Molecular Biology. Chapman and Hall, Panima, New Delhi.

Anderson et al. Molecular Genetics of Photosynthesis, IRL Press, New Delhi.

Hipkins, M.F and Baker N.R. Photosynthesis: Energy transduction a practical approach, IRL Press.

Hopkins, W.G. Introduction to Plant Physiology, Wiley, New York.

Luttuge U. Physiological Ecology of Tropical plants. Springer.

Mengel K. Principles of Plant Nutrition, Panima. .

Salisbury F.B. Plant Physiology. Thomson

Tesar M.B. Physiological basis of crop growth and development, Panima.

Wills R. Post harvest: An introduction to the physiology and handling of fruit.

Nobel P.S. Physiological and environmental Plant Physiology. Allied Press.

Buchanan B.B., Gruissen W. and Jones R.L. Biochemistry and Molecular Biology of Plants, ASPP.

Finkelstein A. Water movement through lipid bilayers, pores and plasma membranes: Theory and reality. Wiley, New York.

Friedman M.H. Principle and models of biological transport. Springer-Verlag.

Stein W.D. Transport and diffusion across cell membrane. Academic press.

Jarvis P.G. and Mansfield T.A. Stomatal Physiology, Cambridge.

Kramer P.J. and Boyer J.S. Water relations of plants and soils. Academic Press. San Diego.

Zimmermann M.H. Xylem structure and ascent of sap. Springer.

Lauchli A. and Bieleski Inorganic plant Nutrition. Springer

Brady N.C. The nature and properties of soils. Macmillan.

Epstein E. Miniral nutrition of plants: Principles and perspectives. Wiley, New York.

Marschner H. Mineral nutrition of higher plants.

Mengel K. and Kirkby E.A. principles of plant nutrition. Worblaufen-Bern, Switzerland.

Luttuge U and Higinbotham N. Transport in plants. Springer-Verlag, Germany

Small J. pH and Plants, an introduction to beginners. Nostrand, New York.

Hall D.O and Rao K.K. Photosynthesis Edwards-Arnold,

Coombs J., Hall D.O., Long, S.P. and Scurlock J.M.O. Techniques in bioproductivity and Photosynthesis. Pergamon, Oxford.
Blankenship R.E. Molecualr Mechanism of photosynthesis Blackwell Science, Oxford.
Edwards G.E. and Walker D. C3-C4 mechanisms and cellular and environmental regulation of photosy nthesis. Univ. California Press.
Pollock C.J., Farrar J.F. and Gordon, A.J. Carbon partitioning within and between organisms. BIOS Scientific, Oxford.
Davies D. The Biochemistry of Plants Academic Press.
Dennis D.T., Turnip D.H., Lefebvre, D.D. and Layzell D.B. Plant Metabolism. Longman, Singapore.
Douce R. Mitochondria in higher plants: Structure, function and Biogenesis. Academic Press.
Douce R and Day D.A. Higher plant cell respiration. Springer, Berlin.
Nicholls D.G. and Ferguson S. J. Bioenergetics. Academic Press.
Dixon R.O.D. and Wheeler C.T. Nitrogen fixation in plants. Chapman and Hall, New York.
Wray J. L. and Kinghorn J.R. Molecular and genetic aspects of nitrate assimilation. Oxford Science, Oxford.
Mann Secondary Plant Metabolites.
Karban R. and Baldwin I.T. Induced response to herbivory. Uni. Chicago press.
Galston A. Life processes of Plants. Sci. Am. Library, New York.
Kendrick R.E. and Frankland B. Phytochrome and Plant Growth. Edward-Arnold, London.
Smith H. Phytochrome and photomorphogenesis: An introduction to the photocontrol of plant development. McGraw Hill London.
Senger H. Blue light effects in biological systems. Springer, Berlin.
Davies P.J. Plant Hormone and their role in plant growth development. Kluwer, Dordrecht, Netherland.
Bopp M. Plant Growth substances. Springer, Berlin.
Moore T.D. Plant Growth regulators. Kluwer, Dordrecht. The Netherland.
Cherry J.H. Environmental Stress in plants. Springer, Berlin.
Mussel H. and Staples R.C. Stress physiology in crop plants. Wiley New York.
Levitt J. Response of plants to environmental stresses. Academic press, New York.

<u>BOL-205: Lab in Plant Physiology</u> – 1 Credit (1 Credit Practical: 15 sessions; any 10 practicals)

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: Water, organic and inorganic content; Determination of a few macronutrients by Flame photometer, 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: chloroplasts and 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 Proline under stress and normal conditions.

BOC-301: Plant Molecular Biology – 4 Credits (3 Credits Theory: 45 hours + 1 Credit Tutorial: 15 hours)

Objectives: The paper deals with various molecular biological processes of DNA replication, transcription and translation. Molecular biology of recombination, synthesis and processing of various RNA molecules are discussed. Further the paper provides deeper understanding of regulation of gene expression in various organisms.

Pre-requisite: Knowledge of the subject at UG level.

Syllabus:

1. **Introduction to Molecular Genetics and 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. **(6L)**
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. **(7L)**
3. **Molecular Biology of Recombination:** Molecular mechanisms of Recombination, Gene conversion, Mismatch repair, the Holliday model of recombination, Single strand break & repair model. **(3L)**
4. **Transcriptions:** Enzymes in transcriptions; Basic features of transcription, Initiation elongation and termination, promotors and enhancers; prokaryotic and eukaryotic transcription. **(8L)**
5. **Regulation of Gene Expression:** Regulation of gene expression in prokaryotes and Eukaryotes. 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. **(7L)**
6. **RNA Molecules and 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). **(6L)**
7. **The Genetic Code and 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. **(6L)**

Reference Books

Burton E. Tropp. 2012. Molecular Biology. Fourth Edition. Jones and Bartlett India Pvt. Ltd, New Delhi.

David Freifelder. 1990. Molecular Biology. Second Edition. Narosa Publishing House, New Delhi.

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.

Primrose, S. B. and R. M. Twyman. 2009. Principles of Gene Manipulation and Genomics. Seventh Edition. Blackwell Publishing, U.S.A.

Brown T. A. 2007. Genomes. Third Edition. Garland Science Publishing, New York. U.S.A.

Benjamin Lewin. 2008. GENES IX. Jones and Bartlett Publishers, London, UK.

Mary A. Schuler and Raymond E. Zielinski. 2005. Methods in Plant Molecular Biology. Academic Press, USA.

R. J. Henry. 2005. Practical Applications of Plant Molecular Biology. Chapman & Hall, London, UK.

Shaw, C. H. 1988. Plant Molecular Biology, Practical Approach. IRL Press, Oxford, Washington DC.

Grierson D and S. Covey. 1984. Plant Molecular Biology. Panima Educational Agency, New Delhi.

Gloria Coruzzi. 1994. Plant Molecular Biology - Genetic Analysis of Plant Development and Metabolism. Springer-Verlag, New York, London.

Tewari, K. K. and G. S. Singhal. 1997. Plant Molecular Biology and Biotechnology. Narosa Publishing House, New Delhi.

BOC-301: Lab in Plant Molecular Biology – 1 Credit (1 Credit Practical: 15 sessions)

Objectives: To learn and understand various molecular biological methods, techniques and hands on experiments with instruments such as PCR, gel electrophoreses etc.

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 system. **(1P)**
5. Amplification of genomic DNA using ISSR/ RAPD random primers in PCR and agarose gel electrophoresis of amplified products and detect and photograph the banding patterns under gel documentation system and analysis of bands to understand genetic variation in plants. **(3P)**
6. Selection of gene sequences from NCBI and construction of phylogenetic trees using appropriate program. **(1P)**

BOC-302: Plant Genetic Engineering – 4 Credits (3 Credits Theory: 45 hours + 1 Credit Tutorial: 15 hours)

Objectives: This course is designed to understand basic principal, tools, techniques and recent advances in plant genetic engineering. After completing this course student should be able to understand basic principle of plant genetic enginering in order to develop and velidate transgenic plants. Students will be exposed to isolation of DNA/RNA, restrction enzymes, vectors (plasmids, phasemids, *etc*), joining and construction of genome and cDNA library and its screening for desired gene, transformation, *etc.* Student will also be exposed to site directed mutation techniques and other modern techniques such as PCR, RT-PCR, *etc* to study gene amplification and their expression. This paper also discusses other application of genetic engineering such as genetic marking and Molecular taxonomy.

Pre-requisite: Knowledge of the subject at UG level.

Syllabus:

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. **(9L)**
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. **(6L)**
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. **(6L)**
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. **(9L)**
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. **(6L)**
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. **(6L)**
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. **(2L)**

8. Field testing of transgenic plants; Bio-safety issues in Indian contest; Indian rules, regulation and procedures for handling transgenic plants. **(1L)**

Reference Books

David Freifelder. 1987. Molecular Biology. Second Edition. Narosa Publishing House, New Delhi.

R. W. Old and S. B. Primerose. Principles of Gene Manipulation. An Introduction to Genetic Engineering.

Benjamin Lewin. 1999. GENES VII. Oxford University Press.

O'Brien, L. and R. J. Henry. Transgenic cereals. 2000. American Association of Cereal Chemists, St. Paul, Minnesota, USA.

Shaw, C. H. 1988. Plant Molecular Biology-Practical Approach. IRL Press, Oxford, Washington DC.

Grierson D and S. Covey. 1984. Plant Molecular Biology. Panima Educational Agency, New Delhi.

Gloria Coruzzi 1994. Plant Molecular Biology-Genetic Analysis of Plant Development and Metabolism. Springer-Verlag, New York, London.

Tewari, K. K. and G. S. Singhal.1997. Plant Molecular Biology and Biotechnology. Narosa Publishing House, New Delhi.

Books refer in BOC-301 Plant Molecular Biology should also be read.

BOL-302: Lab in Plant Genetic Engineering – 1 Credit (1 Credit Practical: 15 sessions; any 10 practicals)

1. Culture of plasmid and maintaining of a culture. **(2P)**
2. Purification of: plasmid and cyanobacteria/algae, plant DNA and, Plant RNA. **(3P)**
3. Quantitative and qualitative determination of DNA preparation. **(1P)**
4. Agarose gel electrophoresis and gel analysis using gel document system. **(2P)**
5. Digestions of DNA by restriction enzymes and size fractionation of fragments. **(1P)**
6. Ligation of digested fragments. **(1P)**
7. RNA isolation from plasmid/cyanobacteria/algae, quantification and running of natured and denatured gel. **(1P)**
8. cDNA formation using reverse transcriptase. **(1P)**
9. PCR cycle for amplification of the isolated cDNA. **(2P)**
10. Semi-quantitative analysis of one of the gene (SOD). **(1P)**
11. RT-PCR quantitation of selected gene(s) using SYBRG. **(2P)**
12. Use of software for quantitation of gene and compare the expression level. **(2P)**
13. Primer designing. **(2P)**
14. Southern Blotting. **(1P)**
15. Northern Blotting. **(1P)**
16. Western Blotting. **(1P)**
17. Creating a transformant using commercial construct. **(2P)**
18. 16 or 18s rRNA analysis. **(2P)**
19. Leaf disc transformation using *Agrobacterium*, establishment of transgenic plants and GUS staining of GFP viewing. **(2P)**

BOC – 401: Cytogenetics and Plant Breeding – 4 Credits (3 Credits Theory: 45 hours + 1 Credit Tutorial: 15 hours)

Objectives:

The paper provides the students with detailed concepts of cytogenetic and Plant breeding. The laboratory exercises are designed so that the students are able to practically perform what is learnt in the theory.

Pre-requisite: Knowledge of the subject at UG level.

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)**

Reference Books

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

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

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

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

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

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

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

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

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

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

BOL-401: Lab in Cytogenetics and Plant breeding – 1 Credit (1 Credit Practical: 15 sessions)

1. Mitotic studies in suitable material. Squashing of the root tip and selection of metaphase plate. **(1P)**
2. Mitotic studies in suitable material*:* Camera Lucida drawing, Karyotype analysis, ideogram and derivation of karyotypic formula. **(3P)**
3. Preparation of metaphase plate and chromosome count in *Urginea indica.* **(2P)**
4. Meiosis in *Allium cepa.* **(1P)**
5. Meiosis in translocation heterozygotes – *Rheo bicolor*. **(2P)**
6. Observation of B chromosomes in suitable material – *Zea mays.* **(1P)**
7. Centre of origin of some economically important crop plants. **(1P)**
8. Floral biology of *Oryza sativa*. **(1P)**
9. Floral biology of *Zea mays.* **(1P)**
10. Effect of chemical mutagen (DES/HZ/EMS) on germination, growth and yield characteristics *Brassica sp. /Impatiens balsamina.* **(1P)**
11. Crossing techniques in *Oryza sativa.* **(1P)**
12. Crossing techniques in *Zea mays.* **(1P)**
13. *In vitro* study of anther/pollen culture technique using suitable material. **(3P)**
14. Induction of polyploidy using Colchicin. **(2P)**

OPTIONAL COURSES

BOO-101: Techniques and Instrumentation in Botany – 4 Credits (3 Credits Theory: 45 hours + 1 Credit Practical: 15 sessions)

Objectives: This paper teaches basic of various types of techniques and instrumentation such as spectrophotmetry, chromatotgraphy, electrophoresis, scintillation and centrifugation to carry out routine and advance research in Botany/Life Science. The emphasis is on principle of the technique, instrumentation design, methodology of sample preparation and handling of equipment and application in the field of Botany. In addition to the above, paper also discusses mole concept, preparation of various solutions and buffers. After completion of the paper students should be able to independently work on various instruments and understand their principle. Also students should be able to prepare various types of solutions and calculate mole fraction, molality, molarity, etc.

Pre-requisite: knowledge of chemistry, biochemistry, instrumental techniques at UG level.

Syllabus:

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. **(3L)**
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. **(3L)**
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. **(12L)**
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. **(9L)**
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). **(12L)**
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. **(3L)**
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. **(3L)**

Reference Books

Bauman R.P. Absorption Spectroscopy. John Wiley, New York

Dixon R.N. Spectroscopy and Structure. Mathuen, London

Sacks R.D. Emission Spectroscopy. John Wiley, New York

Pesez M and Bartos J. Colorimetric and Fluorometric Analysis of Organic Compounds and drugs, Dekker, New York.

Becker R.S. Theory and interpretation of fluorescence and phosphorescence, Wiley interscience, New York.

Guilbault G.G. Practical Fluorescence: Theory, methods and Techniques. Dekker, New York.

Dean J. and Rains T. Flame emission and atomic absorption. Dekker, New York.

Brech F. Analysis in instrumentation. Vol. 6. Plenum, New York.

Bell R. J. Introductory Fourier Transform spectroscopy. Academic Press, New Yrk.

Colthup N.B., Daly L.H. and Wiberley S.E. Introduction to Infra-red and Raman Spectroscopy 2nd Ed. Academic Press. New York.

Kolthoff I.M. and Elving P.J. Treatise on analystical Chemistry, Wiley Interscience, New York.

Williams D.A.R. and Mowthorpe D.J. Nuclear Maganatic Resonance Spectroscopy. John Wiley, New York.

Watson I.J. Introduction to Mass spectroscopy, Raven, New York.

Giddings J.C. Principles and Theory, Dynamics of Chromatogtraphy Part I Dekker, New York.

Grob R.L. Modern Practices of Gas Chromatography. 2nd Ed. John Wiley, New York.

Simpson C.F. Techniques in liquid chromatography, Wiley-Heyden, New York.

Horvath C. HPLC Vol.I Academic Orlando. F.L.

Fritz J.S., Gjerde D.T. and Pohlandt C. Ion chromatography, A. Huthig, Heidelberg

Yau W. W., Kirkland J.J. and Bly D.D. Modern size exclusion chromatography, Wiley Interscience, New York.

Bailey P.L. Analysis and ion selective electrodes 2nd Ed. Heyden, London.

Bates R.G. Determination of pH: Theory and Practices, 2nd Ed. John Wiley, New York.

Willard H.F., Merritt L.L., Dean, J.A. and Settle F.A. Instrumental Method of analysis. CBS Publishers and distribution, New Delhi

Sharma, B.K. Principal of analytical chemistry, Merut Publication, Merut.

Hames B.D. and Rickwood D. Gel electrophoresis of Proteins: A practical Approach 2nd Ed. IRL Press, Oxford.

Practicals:

1. Preparation of molar and other solution and setting of pH.
2. Absorption spectra of various compounds to understand λ max, substance absorption.
3. Verification of Beer's law.
4. pKa value of a buffer/ amino acids using pH meter.
5. IEF* (learning of gel formation and role of various components.)
6. SDS-PAGE of membrane proteins* (learning of gel formation, *etc*.).
7. Drying and analysis of gel.

8. Separation of organelles based on density gradient centrifugation (Using percoll or sugar gradient).
9. TLC for separating and identifying biomolecules.
10. GC*; HPLC*.
11. Fluorescence spectrophotmetry.
12. Flame photometry.
13. Atomic absorption spectrophotometry*.
14. Scintillation counter*.
15. Centrifuges and rotor heads.

* **Demostration Only**

BOO-102: Bioinformatics and Chemoinformatics –4 Credits (2 Credits Theory: 30 hours + 2 Credits Practical: 30 sessions)

Objectives: This interdisciplinary credit course has focus on rapidly advancing fields of basics of bioinformatics (stress on genomics and proteomics) and chemoinformatics (stress on drug design) incorporating many hands on practice lessons with a wide range of public domain software tools, demos and mini projects assisting the students to pick up the minimum required skill sets demanded by bioknowledge based industries.

Pre-requisite: Good knowledge of computers, Internet, Modern biology and biochemistry.

Bioinformatics:

1. Introduction to Bioinformatics, Nature of biological data, Overview of available Bioinformatics resources on the web, NCBI/EBI/EXPASY etc. **(3L)**
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, Database search engines, Entrez , SRS. **(3L)**
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. **(3L)**
4. DNA and Protein Microarrays. **(1L)**
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. **(2L)**
6. Principles of protein folding and methods to study protein folding. **(1L)**
7. Maromolecular interactions, Protein-Protein, Protein-Nucleic acids, Protein- carbohydrates. **(1L)**
8. Introduction to Molecular modelling methods. **(1L)**

Chemoinformatics:

1. Role of Chemoinformatics in pharmaceutical/chemical research, Integrated databases, HTS analysis, Ligand based design of compounds, Structure based design of compounds. **(2L)**
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. **(2L)**
3. Chemical Databases: Design, Storage and Retrieval methods. **(2L)**
4. Introduction to database filters, property based and (drug-like)-Lipinski Rule of Five. **(1L)**
5. Search techniques, similarity searches and clustering. **(1L)**
6. Modeling of small molecules and methods for interaction mapping. **(1L)**
7. Characterization of chemicals by Class and by Pharmacophore, application in HTS Analysis. **(1L)**

8. Introduction to pharmocophore, Identification of pharmacophore features, Building pharmacophore hypothesis, Searching databases using pharmacophores. **(2L)**
9. Overview of Quantitative Structure Activity Relationship and application to Hit to lead optimization. **(1L)**
10. Chemoinformatics tools for drug discovery-Integration of active drugs, Optimization techniques, filtering chemicals, In silico ADMET; QSAR approach, Knowledge-based approach. **(3L)**

Practicals:

Bioinformatics: (15 sessions)

1. Exploring NCBI database system, querying the PUBMED and GenBank databases, EBI server and searching the EMBL Nucleotide database, Exploring & querying SWISSPROT & UniProtKB. **(2P)**
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. **(2P)**
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. **(3P)**
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 and structural properties. **(2P)**
5. **Exploring and using the derived databases:** PROSITE, PRINTS, BLOCKS, Pfam and Prodom for pattern searching, domain searches, etc. **(1P)**
6. **Search and retrieval:** genomic and OMIM data at NCBI server, Exploring the Database & searches on PDB and CSD, WHATIF, Interpreting DNA and Protein microarray data. **(1P)**
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. **(2P)**
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. **(2P)**

Chemoinformatics: (15 sessions)

1. Introduction to basic chemoinformatics software/tools-ACDsketch, Chemsketch, Jchem VegaZZ etc. NCL's moltable, Chembiofinder.**(3P)**
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. **(2P)**
3. Importance of 3D structure and methods available for 3D structure generation- CORINA and CONCORD. **(2P)**

4. A brief introduction to database (ISIS Base) with special emphasis on the storage of chemical in the database format. **(2P)**
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. **(3P)**
6. Representing SMARTS, Recursive and Component level SMARTS and linear representation of chemical concepts like Pka, pH, Zwitterions, Functional Groups, Aromaticity. **(2P)**
7. Molecular docking-Drug docking basics. **(1P)**

Reference Books

Baxevanis, A. D. and Ouellettee, B. F. F. 2002. Bioinformatics: A Practical Guide to the analysis of Genes and Proteins. (2nd Ed.), New York, John Wiley & Sons, Inc. Publications.

Attwood, T. K. and Parry-Smith, D. J. 2001. Introduction to Bioinformatics Delhi. Pearson Education (Singapore) Ptd. Ltd.

Mount, David. 2004. Bioinformatics: Sequence and Genome Analysis. New York, Cold Spring Harbor Laboratory Press.

Baxevanis, A. D., Davison, D. B., Page, R. D. M. and Petsko, G. A. 2004. Current Protocols in Bioinformatics by, New York, John Wiley & Sons Inc.

Philip E. Bourne and Helge Weissig. 2003. Structural Bioinformatics - Methods of biochemical Analysis V. 44. New Jersey. Wiley-Liss.

Jan Drenth. 1994. Principles of protein X-ray Crystallography, Springer-Verlag.

Branden, Carl and Tooze, John. 1991. Introduction to Protein Structure**,** Garland Publishing.

Andrew Leach. 2001. Molecular Modeling: Principles and Applications, Prentice Hall.

Friesner, R.A. Ed., Prigogine, L. Ed. and Rice, S.A. 2002. Computational methods for protein folding : advances in chemical physics vol. 120. New York. John wiley & sons, Inc. Publication.

J.A. McCammon and S.C. Harvey . Dynamics of Proteins and Nucleic Acids. Cambridge University Press, 1087.

Creighton T. E. 1989. Protein Structure: A Practical approach.

Creighton T. 1992. Protein Folding.

Sternberg M.J.E. 1996. Protein Structure Prediction: A practical approach.

Hans Dieter and Didier Rognan. 2003. Molecular Modeling: Basic Principles and application. Wiley VeH Gmbh and Co. KGA.

Fasman, G.D. 1989. Prediction of protein structure and the principles of protein conformation**.** New York. Plenum Press.

Heilmeyer, L. and Friedrich, P. 2001. Amsterdam Protein modules in cellular signaling edited. IOS Press.

Hill, H.A.O., Sadler, P.J., Thomson and A.J Berlin. 1999. Metal sites in proteins and models Springer.

Webster, D. M. Ed. 2000. Protein structure prediction: methods and protocols, Totowa Humana Press, 2000.

Gimona, G. Cesareni and Yaffe, M. Sudol (EDS.). 2004. Modular protein domains, USA, Wiley-vch verlag gmbh & co. 3-527-30813-X .

Holtje, H.D. and Folkers, G. Weinheim. 1997. Molecular modeling: basic principles and applications**,** VCH.

Hans Dieter and Didier Rognan. 2003. Molecular Modeling: Basic Principles and application**,** Wiley VeH Gmbh and Co. KGA.

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.). 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., Mediraттta, N. and 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.

Barry A. Bunin, Brian Siesel, Guillermo Morales Jürgen Bajorath, and Springer. 2009. Chemoinformatics: Theory, Practice & Products.

Konstantin V. Balakin Sean Ekins and Wiley. 2009. Pharmaceutical Data Mining: Approaches and Applications for Drug Discovery.

Alexandre Varnek and Alexander Tropsha. 2008. Chemoinformatics: An Approach to Virtual Screening , Royal Society of Chemistry.

J. bajorath (ed.). 2004. Chemoinformatics: Concepts, Methods, and Tools for Drug Discovery (Methods in Molecular Biology), Humana Press.

Johann Gasteiger and Thomas Engel. 2004. Chemoinformatics.

Andrew R. Leach and Valerie J. Gillet. 2003. An introduction to Chemoinformatics, Kluwer Academic Publisher.

Johann Gasteiger. 2003. Handbook of Chemoinformatics. From Data to Knowledge.

Barry K. Lavine. 2005. Chemometrics and Chemoinformatics, ACS Symposium series 894.

Gundertofte, K. and Jorgensen, F.S. 2000. Molecular modelling and prediction of bioactivity, 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/

BOO - 103: Oenology (Wine Science and Technology) – 2 Credits (1 Credit Theory: 15 hours + 1 Credit Practical: 15 sessions)

Objectives: strongly backed by local winemakers and industries and tourism departments this short course covers the basics of wine and winemaking (enology) and the chemistry behind the process and all basic aspects of wine culture, history, anthropology, service, tasting and toasting wines and also delves on microvinification or small scale fruit wine production. A few demos would be given and a visit to local wineries would be organized.

Pre-requisite: Basic knowledge of fermented beverages and their cultural role.

Syllabus:

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. **(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. **(1L/demo*)**

Practicals:

1. Production of tropical fruit wines.
2. Monitoring of wine production process.
3. Organosensory evaluation of fruit wines.
4. Report on wine brands and wine marketing.

***For demos**: visit to be organised to local wineries: Le Meredien Distillry & Winery, Vinicola, Margao; Cazcar, Nanoda; wine tasting sessions.

Reference Books

Amerine, M. A., Berg, H. W., Kunkee, R. E., Ough, C. S., Singleton, V. L. and Webb, A. D. 1980. The Technology of Winemaking. 4th edition. AVI Publishing Co. Inc. Westport.

Amerine, M. A. and Roessler, E. B. 1983. Wines: Their sensory evaluation. WH Freeman & Co. San Francisco.

Amerine, M. A. and 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.

Boulton, R. B., Singleton, V. L., Bisson, L. F. and Kunkee, R. E. 1996. Principles and Practices of Winemaking. Chapman and Hall, New York.

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Jackson, R. S. 2000. Wine Science: Principles, Practice, Perception. Second Edition. Academic Press, Inc., 525 B Street, Suite 1900, San Deigo, California.

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Storm, D. R. 1997. Winery utilities: planning, design and operation. Chapman & Hall, New York.

Vine, R. P. 1981. Commercial Winemaking, Processing and Controls. AVI Publishing Co., Westport, CT.

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.

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Enological websites

Academic study of winemaking from the University of California, Davis
http://www.wineserver.ucdavis.edu
web site for american journal of enology and viticulture.
http://www.ajevonline.org
Internet journal of viticulture and enology
infowine
http://www. infowine.com

BOO-104: Mine Wasteland Management – 1 Credit (1 Credit Theory: 15 hours)

Objectives: To train students on various aspects of mine waste reclamation strategies.

Pre-requisite: Basic knowledge of ecological impact on local environment.

Syllabus:

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)**

BOO-105: Practical Course in Plant Identification – 1 Credit (1 Credit Practical: 15 sessions)

Objectives: This practical course aims at developing basic skills in identification of flowering plant species using Floras, keys and monographs. Basically aimed at students other than the botany background, it is designed in such a way that even botany students could gain from this. Pre-requisite: Any graduate willing to learn the fundamentals.

Pre-requisite: Basic knowledge of plant taxonomy.

Syllabus:

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

BOO-201: Plant-Animal Interactions – 4 Credits (4 Credits Theory: 60 hours)

Objectives: Plants and Animals form major groups of living organisms in the World. Myriads of interactions between them are the drivers of evolution. Due to compartmentalization of biological sciences into various disciplines into Botany, zoology, Microbiology etc. has denied the opportunities for students to learn these interactions. This course bridges this gap and throws light on the application of this knowledge in the areas of biodiversity conservation, pollination, crop productivity, biological control, bioprospecting, etc. At the end of the course students would have learnt these interactions, these interactions and drivers of evolution, and their value in biodiversity, conservation, productivity (horticultural) and bioprospecting.

Pre-requisite: Either basic degree in biology or student of Masters Programme in any of the life science areas.

1. **Diversity of Plant-Animal interactions:** Mutualism, Antagonism, Commensalism, Competition, 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. **(7L)**
2. **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. **(10L)**
3. **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, behaviour. Factors limiting reciprocal, plant and animal specializations. Seed shadow; seed predators. **(8L)**
4. **Herbivores and green plants:** Nutritional requirements of insects, seasonal and temporal distribution of nutrients in plant parts; Co-evolutionary arms race – plant defence and animal response; plant defence against herbivores – physical, chemical and 'third party' defences; animal responses – behaviour, 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. Hormonal interaction between plants and animals; hormone signaling in trophic interactions; animal pheromones and defense substances. **(15L)**
5. **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. **(7L)**

6. **Carnivorous plants:** Mechanisms of interaction between carnivorous plants and animals, trap mechanisms; nutritional benefits of carnivory, cost-benefit analysis. Evolutionary pathways to carnivory. **(4L)**
7. **Plant communities as animal habitats:** Adaptations, ecological segregation within and between habitats; mechanisms of habitat selection, habitat selection theory, characteristics of plant resources and animal population dynamics, effects of plants on animal spacing and aggression. Animal diversity in relation to plant resource characteristics. Impact of invasive plants on native plant-animal interactions. **(6L)**
8. Plant-animal interactions in agricultural ecosystems. **(3L)**

Reference Books

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Schaefer, M.H. and G.D. Ruxton. 2011. Plant-Animal Communication. Oxford University Press.

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

Waser, N.M. and J. Ollerton. 2006. Plant-Pollinator Interactions: From Specialization to Generalization.University of Chicago Press.

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

BOO-202: Ethnobotany – 2 Credits (2 Credits Theory: 30 hours)

Objectives: To impart ethnobotanical knowledge, methods of collecting ethnobotanicl data and commercial use of traditional knowledge is given in this paper.

Syllabus:

1. **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. **(5L)**
2. Distribution of tribes in India. Knowledge of tribes of Konkan, Goa and Kanara; Ethnobotanical works on these tribes. **(5L)**
3. **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. **(5L)**
4. **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. **(5L)**
5. 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. **(5L)**
6. Traditional knowledge (TK) in relation to Intellectual Property Rights and Biopiracy. Equitable Benefit sharing models of the world. **(5L)**

Reference Books

Alexiades, M. 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.

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BOO-203: Mycological Techniques – 4 Credit s (3 Credits Theory: 45 hours + 1 Credit Practical: 15 hours)

Objectives: Introduce students to important techniques in basic and applied mycology.

Pre-requsite: Knowledge of basic mycology/microbiology at UG level.

Syllabus:

1. **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. **(15L)**
2. **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. **(12L)**
3. **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. **(18L)**

Practicals: (**One credit: 15 sessions of any 10 practicals)**

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.

Reference Books

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Bridge, P.D. (1998). Applications of PCR in Mycology, CABI, UK.

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Heather Angel. (1975). Photographing Nature-Fungi, Fountain press, UK.

J. D. Desai and A. J. Desai (1980). Methods in Microbiology-Microscopy and Staining, Prashant Pub.

Bhat, D. J. (2010). Fascinating Microfungi (hyphomycetes) of Western Ghats-India, Broadway Book Centre, Goa.

Sathe A. V., Deshpande S. , Kulkarni, S. M. and J. Daniel. (1980). Agaricales (mushrooms) of south west India, MACS, Pune.

BOO-301: Applied Phycology – 2 Credits (2 Credit Theory: 30 hours)

Objectives: Paper provides culture and cultivation practices for algae which are of industrial importance. Applications of algae in food, pharmaceuticals and in environmental managements such as waste treatments, agriculture etc. is included in this paper. Adverse impacts of algae such as toxic blooms and bio-fouling is also addressed.

Pre-requisite: Knowledge of algae.

Syllabus:

1. **Algae For Food And Food Supplements:** Scientific basis and Techniques of Mariculture; Porphyra as food: Cultivation and economics, Food and other uses, development of cultivation methods, present and future trends; Cultivated edible kelps: Edible products, kelp composition, kelp production methods, world production; Food and food products from seaweeds; Cultivation of Seaweeds in India; *Spirulina* as human food: Nutritional aspects, Benefits and Village scale production; Public health aspects of microalgal products and maintaining sanitary quality. **(11L)**
2. **Algae in Industry, Environmental Management, Agriculture and Research:** Commercial production and application of phycocolloids: Hydrocolloids History, Chemistry production and Application, future aspects of alginates, Carrageenans, Agars; Lipids and polyols from microalgae History of microalgal lipid production research, Triacylglycerots, Hydrocarban, algal solar energy conversion, carotenoids Polyols; 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; Hydrogen production by algae: water splitting Role of algae in hydrogen production, principles of photosynthetic hydrogen production, Bio-photolysis of water; Pigments from algae; Products from fossil algae: Diatomite-industrial mineral, Calcareous algae, Algal organics and Bio-stratography: algal kerogen in petroleum and coal, Bio-stratigraphy; Biodiesel from algae; Algae and Agriculture: Free living cyanobacteria and algalization, *Azolla*, Microalgal soil conditioners, Micro algal plant growth regulators, Seaweed use in agriculture and horticulture; Algae in space: Algae and life support systems; Algae and planetary biology, Future of algae in space. **(13L)**
3. **Adverse impacts of Algae:** Marine dino-flagellates blooms: dynamics and impacts: Bloom dynamics: Initiation, growth, maintenance, Termination, Ecological and Economic impacts: Negative & Positive impacts; Hazards of freshwater blue green algae (Cyano-bacteria) Neurotoxins, Hepatotoxins, other toxins, Medicinal aspects; Human poisoning, contact dermatitis; Marine biofouling: Bacterial, Microalgal & Macroalgal biofouling, control treatments; antifouling coatings. Recent improvements in chemical control Methodology, Biological control, Non-adhesive surfaces. **(7L)**

Reference Books

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McHugh D.J. (2003). A guide to the seaweed industry. *FAO Fisheries Technical Papers* 441, 1-105.

Melis A. and Happe T. (2001). Hydrogen production. Green algae as a source ofenergy. *Plant Physiology* 127, 740-748.

Melis A., Zhang L., Forestier M., Ghirardi M.L. and Seibert M. (2000). Sustained photo-biological hydrogen gas production upon reversible inactivation of oxygen evolution in the green alga *Chlamydomonas reinhardtii*. *Plant Physiology* 122, 127-136.

Molton P.M., Cysewski G.R.. and Anderson D.B. (1980). Algae grown on animal wastes as a source of industrial oils, polysaccharides and animal feed. In Chung (Ed), *Proceedings of the International Symposium on Biogas, Microalgae and Livestock Wastes*, Taipei, Taiwan, pp 381-387.

Nisizawa K., Noda H., Kikuchi R. and Watanabe T. (1987). The main seaweed foods in Japan. *Hydrobiologia* 151-152, 5-29.

Olaizola M. (2000). Commercial production of astaxanthin from *Haematococcus pluvialis* using 25,000-liter outdoor photobioreactors. *Journal of Applied Phycology* 12, 499-506.

Olaizola M. (2003). Commercial development of microalgal biotechnology: from the test tube to the marketplace. *Biomolecular Engineering* 20, 459-466.

BOO-302: Plant Biotechnology – 4 Credits (3 Credits Theory + 1 Credit Practical)

Objective: The paper deals various aspects of Plant Biotechnology. The laboratory exercises are designed so that the students will have practical experience. On completion of the course, the students will be able to perform more confidently.

Pre-requisite: Knowledge of basic biotechnology at UG level.

Syllabus:

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). **(8L)**
2. **Applications 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, *in vitro* establishment of Mycorrhiza; Applications in industries – Secondary metabolites from cell cultures, from immobilized plant cells. **(6L)**
3. **Micropropagation and somaclonal variation:** Clonal propagation or micropropagation; Mechanism of somaclonal variation, Role of somaclonal variation in plant breeding; Applications. **(4L)**
4. **Germplasm conservation:** Modes of Conservation, significance; Cryopreservation: Cryopreservation of plant stock cells - Methods of cryopreservation, cryobank, Pollen bank; Prospects in agricultural and forest biotechnology. **(5L)**
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. **(6L)**
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. **(6L)**
7. **Transgenic Plants:** Selectable marker genes and their use in transformed plants; Transgenic plants for crop improvement; Molecular farming from transgenic plants; transgenic plants to study regulated gene expression; Bioethics in plant genetic engineering. **(3L)**
8. **Gene transfer methods in plants:** Target cells for transformation, vector for gene transfer. *Agrobacterium* mediated gene transfer; selectable and scorable markers (reporter genes), agroinfection and gene transfer, DNA mediated gene transfer (DMGT); Methods of direct gene transfer. **(3L)**
9. **Application of Biotechnology in Agriculture, Forest and human welfare:** Marker assisted selection (MAS); Biofertilizers (Microbial bioinoculants); Biopesticides; Environmental biotechnology; Enzyme biotechnology. **(4L)**

Practicals:

1. Familiarizing with various physical and chemical sterilization techniques.
2. Preparation of solid and liquid nutrient media.
3. Preparation of explants, inoculation and callus development.
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. Embryo culture.
9. Seed culture.
10. Preparation of media for anther/pollen culture and inoculation.
11. Preparation of cell suspension cultures.
12. Study of cell viability methods.
13. Isolation of protoplast.
14. Study of protoplast viability.
15. Root organ culture (ROC) technique.
16. Preparation of synthetic seeds (alginate beads).

Reference Books

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

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

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

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

Rajmohan Joshi 2006. Agricultural Biotechnology. Gyan Books.

H D Kumar 2005. Agricultural Biotechnology. Daya Publishing House.

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

V S Harikumar 2006. Advances in Agricultural Biotechnology. Regency Publishers.

Bhavneet Kaur, C.P. Malik and Chitra Wadhwani 2008. Current Topics in Biotechnology. M.D. Publications, New Delhi.

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

BO0-303: Mycorrhizal Biotechnology – 3 Credits (2 Credit Theory: 30 hours + 1 credit Practical: 15 sessions)

Objectives: The objective of this paper is to familiarize the students with various aspects of Mycorrhizal fungi. The laboratory exercises are designed so that the students will have hands on training in AM research.

Pre-requisite: Basic knowledge of mycology.

Syllabus:

1. **Biofertilizers:** Definition, types, characteristic features, their role and importance in sustainable agriculture. **(2L)**
2. **Mycorrhiza**: Definition and historical perspective; Types of mycorrhizae; Types and classification; Phylogeny; general importance **(3L)**
3. **Mycorrhizal Techniques:** Isolation and pure culture preparation of ecto- and endo-mycorrhizae; Criteria for identification – generic and specific level; Staining techniques; Trap cultures and pure cultures; *in vitro* culture of AM fungi. **(3L)**
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. **Transport processes in AM fungi:** Phosphorus uptake from environment; Plant phosphate transporters; Phosphate transport in AM fungi; Phosphate and Nitrogen interdependency; Carbon transport in AM fungi; storage lipid translocation in AM fungi; global nutrient fluxes in AM fungi. **(5L)**
6. **Role of Phytohormones in AM symbiosis:** Cytokinins, Gibberellins, Ethylene, ABA, Auxins, Salicylic acid, Jasmonic acid; Role of Jasmonates in mycorrhization. **(2L)**
7. **Ecology of AM fungi:** Mycorrhiza formation in field soil; distinguishing fungi within roots; modeling mycorrhiza formation in mixed communities; disturbance effect on fungal diversity. **(3L)**
8. **Production of ectomycorrhizal fungal inoculums and inoculums procedures:** Types of ectomycorrhizal inocula – soil inoculums, spore inoculums, vegetative inoculums; Methods of preparation, inoculums procedures, factors influencing ectomycorrhizal inoculations. **(4L)**
9. **Arbuscular Mycorrhizae in phytoremediation of mining areas and polluted soils:** Mycorrhizae in heavy metal contamination; phytostabilization; phytoextraction; concepts for improving phytoremediation by plant engineering. **(4L)**

Practicals:

1. Isolation of AM fungal spores from rhizosphere soil. **(1P)**
2. Estimation of AM fungal spore numbers. **(2P)**
3. Techniques of staining roots for AM colonization. **(2P)**

4. Histochemical staining for polyphosphate granules in AM fungal hyphae using Toluidine blue O (TBO). **(1P)**
4. Histochemical staining for lipid bodies in AM fungal hyphae and vesicles using Sudan Black. **(1P)**
5. Preparation of AM fungal inocula: trap and pure cultures. **(3P)**
6. Identification of some commonly occurring AM fungal species based on spore morphology**. (3P)**
7. *In vitro* culture of AM fungi. **(2P)**

Reference Books:

Allan, M. F. 1991. The Ecology of Mycorrhizae. Cambridge University Press.

Bacon, C. W. and White, J. H. 2000. Microbial Endophytes Marcel Dekker, New York.

Dwivedi, B. K. and Pandey, G. 1994. Biotechnology in India. Allahabad: Bioved Research Society.

Read, D. J., Lewis, D. H. Fitter, A. H. and Alexander, I. J. 1996. Mycorrhizas in Ecosystems. Oxford University Press.

Rodrigues, B. F. and Muthukumar, T. 2009. Arbuscular Mycorrhizae of Goa – A Manual of Identification Protocols. Goa University, Goa. 135 *pp*.

Schenck, N. C. 1982. Methods and principles of mycorrhizal research. St. Paul Minnesota.

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.

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.

BOO-304: Plant Histochemistry – 3 Credits (2 Credits theory: 30 hours + 1 Credit Practical: 15 sessions)

Objectives: The paper deals with various applications of histochemical and microscopic techniques to understanding the structure and development of plants. Principles, instrumentation and applications of all microscopy is learnt. Methods and procedures for localization of various storage compounds such as carbohydrates, protein, lipids, minerals such as calcium, potassium, iron and other chemical compounds present in different parts of plants using fluorescent and non fluorescent dyes are discussed.

Pre-requisite: Knowledge of Plant anatomy and histology.

Syllabus:

1. **Introduction to basic histology:** Cells and tissues and microorganisms. **(1L)**
2. **General Techniques:** Chemistry and practice of fixation; whole mounts; sectioning-microtomy, cryo and ultra-microtomy; freeze-drying of biological materials. **(2L)**
3. **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. **(8L)**
4. **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. **(3L)**
5. **Polarization microscopy:** Study of structure and components of cell wall, starch, crystals and other anisotropic materials. **(1L)**
6. **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. **(4L)**
7. **Electron microscopy:** Specimen preparation for TEM and SEM. **(1L)**
8. **Enzyme histochemistry:** Localization of esterases; phosphates and other enzymes. **(2L)**
9. **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. **(4L)**
10. **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. **(4L)**

Practicals: (15 sessions based on any 10 practicals)

1. Study of auto-fluorescence in biological specimens using UV, violet, blue and green excitation filters under fluorescence microscopy. **(1P)**

2. Localization of proteins in biological tissues using fluorescent and non-fluorescent dyes. **(2P)**
3. Localization of lipids in biological tissues using fluorescent and non-fluorescent dyes. **(2P)**
4. Study of cell wall structure using the specific fluorochrome like calcofluor white or acridine orange using fluorescence microscopy. **(1P)**
5. Study the distribution of starch in biological specimens using iodine potassium iodide. **(1P)**
6. Study the structure of starch, stomata, crystalline and other anisotropic materials using polarization microscopy. **(1P)**
7. Examination of normal and diseased plant or animal/human tissues using fluorescence microscopy. **(1P)**
8. Localization of nuclei using fluorescent and non-fluorescent dyes. **(2P)**
9. Localization of minerals such as calcium, potassium and iron in biological tissues. **(3P)**
10. Microphotography using bright-field, dark-field, polarization and fluorescence microscopy. **(1P)**
11. Macro and field photography using normal, zoom and macro lenses. **(1P)**
12. Demonstration of image capture, image analysis, measurement of various parameters of cells and tissues using image analyzing software. **(1P)**
13. Demonstration of scanning electron microscopy. **(1P)**

Reference Books:

Meenakshi Chakraborty. 2012. Histology & Histochemistry, Wisdom Press, New Delhi.

Shyamasundari, K. and K. Hanumantha Rao. 2007. Histochemistry in focus. A Source book of techniques and research needs, MJP Publishers, Chennai.

David L. Spector and Robert D. Goldman. 2006. Basic methods in microscopy, Cold Spring Harbor Laboratory Press, Cold Spring Harbor, New York.

Sharma, V. K. 1991. Techniques in Microscopy and Cell Biology, Tata McGraw-Hill Publishing Company Limited, New Delhi.

Lacey, A. J. 1989. Light microscopy in biology a practical approach, IRL Press, Oxford University, UK.

Krishnamurthy, K.V. 1988. Methods in Plant Histochemistry. S. Viswanthan (Printers & Publishers) Pvt. Ltd., Chennai.

Pears, A.G.E. 1980. Histochemistry Theoretical and Applied, Preparative and Optical Techniques. Vol. I. Fourth Edition. Churchill Livingstone. London and New York.

Pears, A.G.E. 1985. Histochemistry Theoretical and Applied. Analytical Technology. Vol. II, Churchill Livingstone. London and New York.

Hayat, M.A. 1986. Basic Techniques for Transmission Electron Microscopy. Academic Press. London and New York.

Clark, G. 1981. Staining Procedures, Williams and Wilkins, Baltimore, USA.

Conn. H.J. 1977. Biological Stains. R. D. Lillie (Ed.) The Williams and Wilkins Co., Reprinted by Sigma Chemical Company, USA.

Jensen, W.A. 1962. Botanical Histochemistry Principles and Practice. W. H. Freeman and Company, San Francisco, USA.

BOO-305: Horticulture, Landscaping and Gardening – 3 Credits (3 Credits Theory: 45 hours)

Objectives: To learn the science and art of growing horticultural plants including designing landscapes and gardens. Also to familiarize with basic techniques, plants that are in the trade.

Pre-requsite: Anyone who had botany as one of the subjects at UG level.

Syllabus:

1. Horticulture and its history. Divisions of horticulture. Role of Nursery and seed industries. History and importance of horticulture in food, medicine, spice, ornamentals and commerce. **(2L)**
2. Important families of horticultural plants as sources of vegetables, fruits, spices, ornamentals and landscaping plants. **(3L)**
3. **Growth and Development:** Seed dormancy, viability and germination. Native and synthetic hormones and other growth regulators, their importance in horticulture, gardening and landscaping. **(3L)**
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 structures. **(3L)**
5. **Irrigation:** Advanced irrigation system such as drip, microtube and sprinkler systems. **(2L)**
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. **(2L)**
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. **(3L)**
8. **Important vegetables and fruits**, their countries of origin, cultivation and importance in Indian trade and economy. Nutritive value of vegetable greens and fruits. Cultivation of spices and medicinal plants. **(3L)**
9. **Pests and Diseases:** Viral, mycoplasmic, bacterial and fungal pathogens and insects and pests of horticultural plants. Insecticides, pesticides, Herbicides, biological control and integrated pest management. Pests in green house and their control. **(4L)**
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. **(5L)**
11. **Aesthetics and horticulture:** Elements and principles of design and landscape architecture; turf production; formal and informal gardens of the world in general and India in particular. Flower beds, borders, lawns, hedges, edges and topiary. **(6L)**
12. **Orchard – Establishment and management:** Importance of fruit and nut trees; locating the orchard; propagation, spacing and harvesting. **(2L)**

13. **Organic farming:** Importance, principles, certification, planting material, soil management, weed management, composting. **(3L)**
14. **Cut flowers:** Cut flower species, culture, packing, marketing. **(2L)**
15. **Post harvest handling:** Post harvest changes, storing, handling, processing and marketing. **(2L)**

BOL-305: Lab in Horticulture, Landscaping and Gardening – 1 Credit (1 Credit Practical: 15 sessions)

Practicals:

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. **(1P)**
2. Visit to local vegetable cultivating plants and learn cultural practices of different vegetable crops. **(1P)**
3. Preparation by cutting and layering. **(1P)**
4. Use of auxins for rooting and grafting. **(1P)**
5. Planning and planting a vegetable garden with local seasonal vegetables and maintenance of a record of their growth. **(1P)**
6. Observation of common diseases and insect pests of horticultural plants around Goa. **(1P)**
7. Knowledge of common herbicides, fungicides and insecticides locally available. **(1P)**
8. Field to places of horticultural gardens and landscaping areas and studios. **(1P)**
9. Visit to gardens/ industries/housing complexes etc. and study the landscaping, hedge plants, ornamentals, foliage plants, lawns, rock gardens, etc. **(3P)**
10. Visit to flower market and record ornamental flowering plants of Goa. **(1P)**
11. Visit to vegetable market and record the vegetables and their origin. **(1P)**
12. Visit to fruit market and record the fruits and their origin. **(1P)**
13. Visit to polyhouses growing vegetables/flowers for study. **(1P)**
14. Visit and study Botanical garden in Goa. **(2P)**

Reference Books:

Acquaah, George. 2009. Horticulture: Principles and Practices (4th Edition). PHI Learning Private Limited.

Adams, C.R., K.M. Banford and M.P. Early. 1990. Principles of Horticulture. Butternorth Heineman Ltd., London.

Agricultural Officer's Association Goa, 2002. Commercial Floriculture in Goa.

Gopalan, C., B.V. Rama Sastri, S.C. Balasubramanian, B.S. Narasinga Rao, Y.G. Deosthale and K.C. Pant. National Institute of Nutrition (ICMR), Hyderabad, India 1996. Nutritive value of Indian foods.

Graf, A.B. 1981. Tropica, 2 nd Edition. Rohers Co. USA.

Hariman, H.T. and D.F. Kestler. 1976. Plant Propagation: Principles and practicals. Prentice & Hall of India. New Delhi.

Agricultural Officer's Association Goa, 2000. Kitchen Garden Manual.

Kumar, N. 1986. Introduction to Horticulture. Rajalakshmi Publication. Nagerkoil, Tamil Nadu.

Agricultural Officer's Association Goa, 1997. Manual for Gardening.

Moore, R. and W.D. Clark. 1995. Botany: Plant form & function, Vol.1.W.M.C.Brown Publisher.

Randhawa and A. Mukhopadhyay. 1982. Floriculture in India. Allied Publications Pvt. Ltd., New Delhi.

Ranjit, S. 1992. Fruits. 2nd Ed. National Book Trust, New Delhi.

Rao, K.Manibushan. 2005. Text Book of Horticulture (2nd Edition). MacMillan India Ltd., New Delhi.

Torres, C. K. 1989. Tissue culture techniques for horticultural crops. Van Nostrand Reinheld. New York.

BOO-401: Fungal Chemistry and Mycoremediation – 2 Credtis (1 Credit Theory: 15 hours + 1 Credit Practical: 15 sessions)

Objectives: Mycoremediation is one of the most complex areas in applied remediation engineering. Scientists began to use fungi and bacteria for the degradation of xenobiotic organic compounds toward the middle of the twentieth century. The use of bacteria showed fast and promising results, but research on evaluating fungi has lagged behind. This does not mean that fungi are not suitable organisms or that they function less satisfactorily than bacteria in degrading such compounds. The participation of fungi in bioremediation is now well established in all ecosystems. During the past two decades, many fungal scientists and engineers have wanted to try using fungi in the degradation of organic compounds, and for those who did try using them, good results were obtained. The discovery of the value of white-rot fungi in bioremediation has brought greater success and has thus stimulated research throughout the world. A new era in the use of fungal technologies for the degradation of organic compounds has begun. This credit course therefore envisages and aims to share the excitement in this new field.

Pre-requisite: Background of mycology, ecology and chemoinformatics.

Syllabus:

1. **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. **(2L)**
2. **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. **(2L)**
3. **Fungal Metabolites Derived from the Citric Acid Cycle:** Introduction, Citric Acid and Related Acids, Fungal Tetronic Acids, Canadensolide and Avenaciolide, Nonadrides, Squalestatins. **(1L)**
4. **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. **(2L)**
5. **Mycotoxins:-**Introduction, Ergotism, Trichothecenes as Mycotoxins, Other Fusarium Toxins, Aflatoxins, Mycotoxins of Penicillium Species, PoisonousMushrooms. **(1L)**
6. **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. **(2L)**

7. Fungal Treatment of Industrial Wastewaters, Distillery and Brewery Wastes. **(1L)**
8. Fungal Metabolism of Petroleum Hydrocarbons, Phenols, Chlorophenols, Pentachlorophenol, Polycyclic Aromatic Hydrocarbons. **(1L)**
9. Fungal Degradation of Polychlorinated Biphenyls and Dioxins, Pesticides. **(1L)**
10. Fungal Lignin Degradation, Decolorization of Pulp and Paper Mill Effluents, Decolorization and Degradation of Dyes. **(1L)**
11. Fungal Biosorption of Heavy Metals. **(1L)**
12. Fungal chemistry and Mycoremediation. **(1L)**

Practicals: (15 sessions of 10 practicals)

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

Reference Books:

Hanson, James. (2008). The chemistry of fungi, Royal Society of Chemistry, 221 pp.

Harbhajan Singh. (2006). Mycoremediation: Fungal bioremediation, Wiley, 608 pp.

Claudio Toniolo and Hans Brockner. (2009). Peptaibiotics: Fungal Peptides Containing alpha-Dialkyl alpha-Amino Acids , Wiley-VCH, 714 pp.

Frisvad. (1998), Chemical fungal taxonomy, CRC press, 424 pp.

Volesky B. (1990). Biosorption of heavy metals, CRC press, 408 pp.

Milbra A. Schweikert and Bruce B. Jarvis (Eds.). (2003). Handbook of Secondary Fungal Metabolites, 3-Volume Set , Academic Press, 2498 pp.

Kuhn P. J. (1990). Biochemistry of Cell Walls and Membranes in Fungi, Springer, 327 pp.

G. D. Robson, Pieter van West and Geoffrey Gadd (Eds.). (2007). Exploitation of Fungi (British Mycological Society Symposia), CUP, 350 pp.

G. M. Gadd. (2001). Fungi in Bioremediation (British Mycological Society Symposia), CUP, 496 pp.

Valdes J.V. (2000). Bioremediation, Springer, 169 pp.
Zhigiang A.N. (2005). Handbook of Industrial Mycology, CRC Press, 763 pp.
S. K. Deshmukh and M.K.Rai. (2005). Biodiversity of fungi: their role in human life, Science Publishers, 460 pp.
G. M. Gadd. (2006). Fungi in biogeochemical cycles, Volume 24 of British Mycological Society symposium series, CUP, 406 pp.

BOO-402: Photosynthesis and Crop Productivity - 2 Credits (2 Credits Theory: 30 hours)

Objectives: To enable the students to learn the various techniques used in photosynthesis and crop productivity.

Pre-requisite: Course in Plant Physiology.

Syllabus:

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, 14^C 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:

Charles-Edwards D.A. Physiological determinants of crop growth. Academic Press, London.

Evans G.C. The quantitative analysis of Plant Growth. Blackwell Scientific, Oxford.

Hunt R. Plant Growth analysis. Studies in biology. Edward Arnold, London.

Sestak Z., Catsky J and Jarvis P.G. Plant Photosynthetic production. W. Junk, Hague.

Johnson C.B. Physiological processes limiting plant productivity. Butterworths, U.K.

Monteith J.L. Vegetation and atmosphere. Academic Press. London.

Woodwards F.I. and Sheehy J.E. Principles and measurements in environmental biology. Butterworths, London.

Jones H.G. Plants and Microclimate. Cambridge.

Grace J. Plant Atmosphere relationships. Outline studies in ecology. Chapman and Hall, London.

Beadle C.L., Long S.P. and Imbamba S.K., Hall D.O. and Olembo R.J. Photosynthesis in relation to plant production in terrestrial environments. Tycooly International, Oxford.

Nobel P.S. Biophysical Plant Physiology and Ecology. W.H. Freeman, San Fransisco.

Wit C.T. de. Photosynthesis of leaf canopies. Verslagen, Wageningen.

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Slavik B. Methods of studying plant water relations. Chapman and Hall. London.

Hill D.W. and Powell T. Non dispersive Infra-red gas analysis in science, medicine and industry. Adam Hilger, London.

Esau K. Anatomy of seed plants Wiley, New York.

Fahn A. Plant Anatomy. Pergamon, Oxford.

Edwards G.E. and Walker D.A. C3-C4 some aspects of photosynthetic carbon assimilation. Blackwell Scientific. Oxford.

Flores E., Ramos J.L., Herrero A and Guerrero M.G. Nitrate assimilation in cyanobacteria. Elsevier, New York.

Paleg L.G. and Aspinall D. The physiology and biochemistry of drought resistance in plants. Academic Press. Sydney.

Carr N.G. and Whitton B.A. The biology of blue green algae. Balckwell. Oxford.

Fogg G.E. Algal culture and phytoplankton Ecology. Uni. Of Wisconsin Press. Madison.

Vogel J.C. Fractionation of the carbon isotopes during photosynthesis. Springer-Verlag, New York.

BOO-403: Phytochemistry - 2 Credits (1 Credit Theory: 15 hours + 1 Credit Practicals: 15 sessions)

Objectives: To introduce students to the interesting world of plant based natural products, the important groups of phytochemicals.

Pre-requisite: Knowledge of botany, plant metabolites at UG level.

Syllabus:

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. **(3L)**
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 and 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:

Qualitative estimation 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.

Reference Books:

Jean Bruneton. 1995. Pharmacognosy, Phytochemistry, Medicinal plants, English edition. Levoisier Publishing, Paris.

Nakanishi Golo. Natural products chemistry.

CHJ Wells (Chapman and Hall). Introduction to Molecular Phytochemistry.

T. Swain. Comparative Phytochemistry, edited**.**

Alfred Burger. Burger's medicinal chemistry edited.

Peach and M.V. Tracey. Modern methods of plant analysis, Vol. I to VII

Scikel runeckles. Recent advances in Phytochemistry – Vol.I to IV– Appletaon century crofts.

Chemistry natural products – Vol. I onwards IWPAC.

Raphel Ikhan. Natural products – A Laboratory guide.

Ernest Guenther and Robert E. Kreiger. The essential oils.

RHF Manske. The Alkaloids : Chemistry & Physiology (Volume)

CHJ Wells. Introduction to Molecular Phytochemistry. (Chapman and Hall)

T. Swain. Comparative Phytochemistry, edited.

Alfred Burger. Burger's medicinal chemistry edited.

Peach and M.V. Tracey. Modern methods of plant analysis, Vol. I to VII.

Raphel Ikhan. Natural products – A Laboratory guide.

Ernest Guenther and Robert E. Kreiger. The essential oils.

RHF Manske. The Alkaloids : Chemistry & Physiology (Volume).

Paul J Schewer. Chemistry of Marine Natural Products.

Dean F. Martin & George Padilla. Marine Phamacognosy.

BOO-404: Glycobiology - 2 Credits (1 Credit Theory: 15 hours + 1 Credit Practical: 15 sessions)

Objectives: Glycobiology is one of the more rapidly growing fields in the natural sciences, with broad relevance to many areas of basic research, biomedicine, and biotechnology. The field includes the chemistry of carbohydrates, the enzymology of glycan formation and degradation, the recognition of glycans by specific proteins (lectins and glycosaminoglycan-binding proteins), glycan roles in complex biological systems, and their analysis or manipulation by a variety of techniques. Research in glycobiology thus requires a foundation not only in the nomenclature, biosynthesis, structure, chemical synthesis, and functions of glycans, but also in the general disciplines of molecular genetics, protein chemistry, cell biology, developmental biology, physiology, and medicine.

Pre-requisite: Good knowledge of chemistry, biology and biochemistry at UG level.

Syllabus:

1. **General Principles:** Historical Background and Overview, Saccharide Structure and Nomenclature, Exploring the Biological Roles of Glycans. **(2L)**
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. **(4L)**
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. **(4L)**
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. **(4L)**
5. **Future perspectives**:-Glycogenes, glycoscience and rational drug design. **(1L)**

Practicals:

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

Reference Books:

Ajit Varki (ed). 2002. Essentials of glycobiology, Cold Spring Harbour Laboratory Press.

R R Townsend and A T Hotchkiss. 1997. Techniques in glycobiology, TF-CRC.

S. A.Dwek and M. V. Schumacher. 2002. Functional and Molecular Glycobiology, Brooks, U.PAP Edition.

Fukuda, Minoru (Edt), **Hindsgaul and Ole** (Edt). 2000. Molecular and Cellular Glycobiology, Paperback Edition.

Thisbe K. Lindhorst. 2007. Essentials of Carbohydrate Chemistry and Biochemistry, Wiley.

Valentin Wittmann. 2007. Glycopeptides and Glycoproteins - Synthesis, Structure, and Application Edited, Springer.

Marco Brito-Arias. 2007. Synthesis and Characterization of Glycosides, Springer.

Maureen E. Taylor and Kurt Drickamer. 2002. Introduction to Glycobiology, OUP.

Natan Sharon, Halina Lis and Springer. 1999. Lectins**.**

R. Doyle, CRC. 1994**.** Lectin-Microroganism interaction.

Ginsburg V. ed. 1972. Complex Carbohydrates, Part B. Methods Enzymol., vol 28. Academic Press, San Diego, California.

Gottschalk A. ed. 1972. Glycoproteins: Their composition, structure and function. Elsevier, New York.

Ginsburg V. ed. 1978. Complex carbohydrates, Part C . Methods Enzymol., vol. 50. Academic Press, San Diego, California.

Lennarz W.J., ed. 1980. The biochemistry of glycoproteins and proteoglycans. Plenum Press, New York.

Ginsburg V. and Robbins P. eds. 1981. Biology of carbohydrates , vol. 1. Wiley, New York.

Ginsburg V. ed. 1982. Complex carbohydrates, Part D. Methods Enzymol., vol. 83. Academic Press, San Diego, California.

Horowitz M. and Pigman W. eds. 1982. The glycoconjugates. Academic Press, New York.

Schauer R., ed. 1982. Sialic acids, chemistry, metabolism, and function. Springer-Verlag, New York.

Ivatt R.J. ed. 1984. The biology of glycoproteins. Plenum Press, New York.

Ginsburg V. and Robbins P. eds. 1985. Biology of carbohydrates, vol. 2. Wiley, New York.

Beeley J.G. ed. 1985. Glycoprotein and proteoglycan techniques. Elsevier, Amsterdam, The Netherlands.

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.

Feizi T. 1989. Carbohydrate recognition in cellular function. Ciba Foundation Symposium, vol. 145. Wiley, New York.

Ginsburg V. and Robbins P. eds. 1991. Biology of carbohydrates, vol. 3. Wiley, New York.

Fukuda M., ed. 1992. Cell surface carbohydrates and cell development. CRC Press, Boca Raton, Florida.

Allen H.J. and Kisailus E.C. eds. 1992. Glycoconjugates: Composition, structure, and function. Dekker, New York.

Fukuda M. ed. 1992. Glycobiology: A practical approach. IRL Press, Oxford, United Kingdom.

Lennarz W.J. and Hart G.W. eds. 1994. Guide to techniques in glycobiology. Methods Enzymol., vol. 230. Academic Press, San Diego, California.

Bock K. and Clausen H. eds. 1994. Complex carbohydrates in drug research: Structural and functional aspects . Munksgaard, Copenhagen, Denmark.

Fukuda M. and Hindsgaul O. eds. 1994. Molecular glycobiology. Oxford University Press, New York.

Alavi A. and Axford J.S. 1995. Advances in experimental medicine and biology, vol. 376, Glycoimmunology. Plenum Press, New York.

Montreuil J., Vliegenthart J.F.G. and Schachter H. eds. 1995. Glycoproteins. Elsevier, New York.

Verbert A. ed. 1995. Methods on glycoconjugates: A laboratory manual. Harwood Academic Publishers, Switzerland.

Townsend R.R. and Hotchkiss A.T. eds. 1997. Techniques in glycobiology. Marcel Dekker, New York.

Iozzo R. ed. 2000. Proteoglycans: Structure, biology and molecular interactions. Marcel Dekker, Inc., New York.

BOO-405: Remote Sensing: Techniques and Applications – 3 Credits (3 Credits Theory: 45 hours)

Objective: To understand the principles of Remote Sensing and theoretical basis of its applications in ecology and environmental studies.

Pre-requisite: Basic knowledge of remote sensing.

Syllabus:

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)**
2. **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. **(8L)**
3. **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)**
4. **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)**
5. **Applications In Forestry 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. **(12L)**

BOL- 405: Remote Sensing: Techniques and Applications – 1 Credit (1 Credit Practical: 15 sessions)

Practicals:

1. Visual Interpretation of Black & White and False colour Multi Band Imagery. **(2P)**

The following practicals are designed based on ILWIS package:

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

Reference Books:

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 and 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 and 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.

http://www.fas.org/irp/imint/docs/rst/Front/tofc.html

Manuals (pdf), data and software available at www.52north.org

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BOO-406: Plant Biochemistry - 4 Credits (3 Credits Theory: 45 hours+ 1 Credit Practical: 15 sessions)

Objective: Introduce the students to biochemical processes and products in plants.

Pre-requisite: Knowledge of plant physiology/biochemistry and UG level.

Syllabus:

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. **(12L)**
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. **(6L)**
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. **(12L)**
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. **(9L)**
5. Signal Transduction pathways – Cell surface receptors, G proteins coupled secondary messenger. **(6L)**

Practicals:

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

BOO-407: Bioentrepreneurship and Innovation – 2 Credits (2 Credits – Theory: 30 hours)
(In association with Goa Chamber of commerce and Industries-GCCI and contributions from self sponsored resource persons from pharma/bioindustry)

Objective: Impart knowledge and work experience based/case study based training to students in the field of innovation and uses of various biology/ biotechnology based products, goods, services employed in bioentrepreneurship.

Pre-requisite: History of scientific ideas, research methodology, biotechnology at UG level.

Syllabus:

1. Entrepreneurship in the Life Sciences. **(2L)**
2. Development of Products in the Biomedical Industry. **(2L)**
3. Integration of science, technology and business. **(2L)**
4. From Lab to land: scope in agro/food processing industry. **(1L)**
5. Industrial management. **(1L)**
6. Market analysis. **(2L)**
7. Business development. **(2L)**
8. Regulatory mechanisms. **(1L)**
9. Indian bioentrprenuerial scenario. **(1L)**
10. Case studies of successful bioentrepreneurs. **(1L)**

Practicals:

Students would be assigned / placed in a typical bioindustry and would work under guidance of the nominee of the company for duration equivalent to 15 periods to produce a report in prescribed format. The report needs to be submitted before end of the semester.

Reference Books:

Abrams Rhonda, (2010). Six-Week Start-Up: A Step-by-Step Program for Starting Your Business, Making Money and Achieving Your Goals! Redwood City: The Planning Shop.

Byrne John A. (2011). World Changers: 25 Entrepreneurs Who Changed Business as We Knew it. New York: Penguin.

Edwards, Paul and Sarah (1999). Working from Home: Everything you need to Know about Living and Working under the Same Roof. New York: Penguin Putman.

Judson Bruce (2004). Go it alone! The Secret to Building a Successful Business on Your Own. New York: HarperCollins.

Little Steven S. (2005). The 7 Irrefutable Rules of Small Business Growth. Hoboken: John Wiley & Sons, Inc. 2005.

Lynn Jacquelyn (2007). The Entrepreneur's Almanac: Fascinating Figures, Fundamentals and Facts at your Fingertips. Canada: Entrepreneur Media Inc.

Mohr Angie (2008). Finance and Grow Your Own Business. North Vancouver: International Self-Counsel Press Ltd.

Ramsey David (2011). EntreLeadership: 20 Years of Practical Business Wisdom from the Trenches. New York: Howard Books.

Ries Eric (2009). The Lean Startup: How Today's Entrepreneurs Use Continuous Innovation to Create Radically Successful Businesses. New York: Crown Business.

Rogak Lisa (1999). Smart Guide to Starting a Small Business. New York: John Wiley & Sons, Inc.

Solovik Susan Wilson, Ellen R. Kadin and Edie Weiner (2011). *It's* Your Biz: The Complete Guide to Becoming Your Own Boss. New York: AMACOM.

Strauss Steven D. (2008). The Small Business Bible: Everything you need to know to succeed in your small business. Hoboken: John Wiley & Sons, Inc.

Kathleen Allen (1995). Launching New Ventures: An Entrepreneurial Approach, Upstart.

Jane Applegate (1992). Succeeding in Small Business: The 101 Toughest Problems and How to Solve Them, Plume/Penguin.

David H. Bangs, Jr. (1992). The Start Up Guide: A One-Year Plan for Entrepreneurs, Upstart.

David H. Bangs, Jr. (1992). The Business Planning Guide: Creating a Plan for Success in Your Own Business, 6th edition, Upstart.

Gordon B. Baty (1990). Entrepreneurship for the Nineties, Prentice-Hall.

Roger Bel Air (1988). How to Borrow Money from a Banker: A Business Owner's Guide, AMACOM.

Thomas P. Bergman (2002). The Essential Guide to Web Strategy for Entrepreneurs, Prentice Hall PTR.

Amar V. Bhidé (2000). The Origin and Evolution of New Businesses, Oxford U. Press.

Bruce Blechman and Jay Conrad Levinson (1991). Guerrilla Financing: Alternative Techniques to Finance Any Small Business, Houghton Mifflin.

Barbara Buchholz, Margaret Crane, and Ross W. Nager (1999). The Family Business Answer Book: Arthur Andersen Tackles 101 of Your Toughest Questions, Prentice Hall.

Tim Burns Break (1999). The Curve: The Entrepreneur's Blueprint for Small Business Success, International Thomson Business Press.

Lawrence Finley (1994). Entrepreneurial Strategies: Text and Cases, PWS-Kent Publishing.

Michael E. Gerber (1998). The E-Myth Manager: Why Management Doesn't Work—and What to Do About It, HarperBusiness.

David Gladstone (1988). Venture Capital Handbook, new and revised edition, Prentice-Hall.

Seth Godin (1998). The Bootstrapper's Bible: How to Start and Build a Business with a Great Idea and Almost No Money, Upstart.

David E. Gumpert (1990). How to Create a Successful Business Plan, Inc. Publishing.

Craig Hall (2001). The Responsible Entrepreneur: How to Make Money and Make a Difference, Career Press.

James W. Halloran (1994). The McGraw-Hill 36-Hour Course in Entrepreneurship, McGraw-Hill.

Robert D. Hisrich and Michael P. Peters (1995). Entrepreneurship: Starting, Developing, and Managing a New Enterprise, 3rd edition, Irwin.

Azriela Jaffe (1998). Let's Go into Business Together: 8 Secrets to Successful Business Partnering, Avon Books.

Guy Kawasaki (1995). How to Drive Your Competition Crazy: Creating Disruption for Fun and Profit, Hyperion.

William Lasher (1994). The Perfect Business Plan—Made Simple, Doubleday Made Simple Books.

James W. Lea (1991). Keeping It in the Family: Successful Succession of the Family Business, Wiley.

Jay Conrad Levinson (1997). The Way of the Guerrilla: Achieving Success and Balance as an Entrepreneur in the 21st Century, Houghton Mifflin.

Jay Conrad Levinson (1984). Guerrilla Marketing: Secrets for Making Big Profits from Your Small Business, Houghton Mifflin.

Charles P. Lickson (1994). A Legal Guide for Small Business: How to Do It Right the First Time, Crisp Publications.

Gary S. Lynn and Norman M. Lynn (1992). Innopreneurship: Turning Bright Ideas into Breakthrough Business for Your Company, Probus Publishing.

Ronald E. Merrill and Henry D. Sedgwick (1993). The New Venture Handbook: Everything you need to Know to Start and Run Your Own Business, new and updated edition, AMACOM.

Bill Meyer (1998). Cash Flow: A Practical Guide for the Entrepreneur, Perc Press.

Linda Pinson and Jerry Jinnett (1996). Steps to Small Business Start-Up: Everything You Need to Know to Turn Your Idea into a Successful Business, 3rd edition, Upstart.

W. R. Purcell, Jr. (1981). Understanding a Company's Finances: A Graphic Approach (a uniquely clear explanation of what financial reports reveal), Houghton Mifflin.

Russell Robb (1995). Buying Your Own Business, Adams Media Corp.

Robert Ronstadt (1988). Entrepreneurial Finance: Taking Control of Your Financial Decision Making, Lord Publishing.

Eric S. Siegel, Brian R. Ford, and Jay M. Borstein (1993). The Ernst & Young Business Plan Guide, 2nd edition, Wiley.

A. David Silver (1993). Cashing Out: How to Value and Sell the Privately Held Company, Enterprise Dearborn.

A. David Silver (1989). Business Bible for Survival: What to Do When Your Company Falls on Hard Times, Prima.

Lawrence W. Tuller (1997). Finance for Non-Financial Managers and Small Business Owners, Adams Media Corporation.

Karl H. Vesper (1990). New Venture Strategies, revised edition, Prentice Hall.

Mel Ziegler, Patricia Ziegler, and Bill Rosenzweig (1992). The Republic of Tea: The Story of the Creation of a Business, as Told through the Personal Letters of Its Founders, Currency Doubleday.

Anthony Scott D. (2012). The Little Black Book of Innovation: How It Works, How to Do It. Boston: Harvard Business Review Press, 281pp.

Berkun Scott (2010). The Myths of Innovation. Sebastopol, CA: O Reilly Media, 225pp.

Napier Nancy K. and Mikael Nilsson (2008). The Creative Discipline: Mastering the Art and Science of Innovation Westport: Praeger, 227pp.

BOO-408: Mushroom biotechnology - 2 Credits (1 Credit Theory: 15 hours + 1 Credit Practical: 15 sessions)

Objectives: Train the students in the field of diversity, biology of mushrooms in wild and biotechnology of mushrooms produced commercially with stress on edible and medicinal species, knowledge on toxic species and focus on mushroom production and marketing.

Pre-requisite: Knowledge of mushrooms at UG level.

Syllabus:

1. Edible and medicinal mushrooms, criteria for edibility, domestication of edible and medicinal mushrooms. **(2L)**
2. Mushroom biotechnology principles- as applied to commercial species (top six). **(3L)**
3. Spawn development and quality parameters, **(1L)**
4. Production and quality management. **(3L)**
5. Harvesting, grading, branding, marketing. **(2L)**
6. Mushrooms-post harvest processing and value addition. **(1L)**
7. Mushroom marketing, scope for new species, scope in tropical countries. **(2L)**
8. Future of mushroom industry-global, national, local perspectives. **(1L)**

Practicals:

1. Identification of edible, medicinal and toxic mushroom species. **(2P)**
2. Preparation of pure cultures and strain evaluation. **(2P)**
3. Production of mushroom spawn. **(2P)**
4. Spawn quality evaluation. **(1P)**
5. Identification and preparation of substrate/compost. **(2P)**
6. Mushroom production and grading. **(4P)**
7. Report on Button and oyster mushroom industry. **(2P)**

Reference Books:

Arora, D. (1986). Mushrooms demystified: A comprehensive guide to the fleshy fungi. Berkeley: Ten Speed Press. 959 pp.

Kuo, M. (2007). 100 Edible Mushrooms. Ann Arbor: University of Michigan Press. 329 pp.

Kuo, M. and A. Methven (2010). 100 Cool Mushrooms. Ann Arbor: University of Michigan Press. 210 pp.

Largent, D. L. (1973). How to identify mushrooms to genus I: Macroscopic features. Eureka, CA: Mad River Press. 86 pp.

Largent, D. L. and Thiers, H. D. (1973). How to identify mushrooms to genus II: Field identification of genera. Eureka, CA: Mad River Press. 32 pp.

Largent, D. L., Johnson, D. and Watling, R. (1973). How to identify mushrooms to genus III: Microscopic features. Eureka, CA: Mad River Press. 148 pp.

Largent, D. L. and Baroni, T. J. (1988). How to identify mushrooms to genus VI: Modern genera. Eureka, CA: Mad River Press. 277 pp.

Lockwood, T. F. (2002). Treasures from the kingdom of fungi. Korea: Taylor Lockwood. 127 pp.

McKnight, K. H. and McKnight, V. B. (1987). Mushrooms (Peterson Field Guides). New York: Houghton Mifflin. 429 pp.

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Money, N. P. (2005). Why picking wild mushrooms may be bad behaviour. Mycological Research 109: 131-135.

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Phillips, R. (1991). Mushrooms of North America. Boston: Little, Brown and Company. 319 pp.

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Rumack, Barry H., and David G. Spoerke (1994). *Handbook of mushroom poisoning: diagnosis and treatment*. CRC Press, 1994.

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Penn State Handbook for Commercial Mushroom Growers. Penn State University. University Park, Pennsylvania, U.S.A. 16802. 130 pp.

Rinker, D.L. Commercial Mushroom Production. Ontario Ministry of Agriculture and Food, Parliament Buildings, Toronto, Ontario.

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Vedder, P.J.C. (1978). Modern Mushroom Growing. Grower Books. 50 Doughty Street, London, England WCIN 2LP. 420 pp.

Ram Dutta, Satish (2007). Advances in Mushroom Science: Serial Pub, 2007, 240 p,

T. N. Lakhanpal, Onkar Shad and Monika Rana (2010). I. K. Biology of Indian Morels: International, 2010, 266 pp.

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S. Kannaiyan, T. Marimuthu and K. Lenin (Ed), Diversity and Production of Edible Mushrooms: Associated Publishing Company, 2011, 184 pp.

Engineers India Research Institute, (2006). Hand Book of Mushroom Cultivation, Processing and Packaging, 256 pp.

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B.C. Suman and V.P. Sharma (2005). Mushroom: Cultivation, Processing and Uses:, Agrobios, 349 pp.

J. K. Singh (2012). Mushroom: Diseases and Its Control: Enkay Pub, 264 pp.

Nilanjana Das (2008). Mushroom: Its Wild Relatives: Researchco Book Centre, 174 pp.

S.K. Singh and P.K. Jha (2014). Mushroom: Production and Utilization: Scientific Publishers, 2014, 189 pp.

J. K. Singh (2011). U.K. Prasad and Anshu Priyadarshini, Mushroom: The Future Vegetable: Cultivation, Processing and Marketing Enkay Publishing House, 270 pp.

B. C. Suman and V. P. Sharma, (2014). Mushroom Cultivation in India: Daya, Reprint, 180 pp.

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S. C. Dey (2004). Mushroom Growing: Agrobios, 92 pp.

V.N. Pathak, Nagendra Yadav and Maneesha Gaur (2011). Mushroom Production and Processing Technology: Agrobios, 180 pp.

M. N. Jha and Dayaram (2004). Mushrooming of Mushroom: Today and Tomorrow's printers, 2004, 132 pp.

S. Biswas, M. Datta, S. V. Ngachan (2007). Mushrooms: A Manual For Cultivation: PHI Learning, 220 pp.

R. C. Ram Aavishkar (2007). Mushrooms and Their Cultivation Techniques. 164 pp.

B. N. Verma, Prem Kumar Prasad and K. K. Sahu (2013). Mushrooms: Edible and Medicinal Cultivation Conservation Strain Improvement with their Marketing: Daya, 431 pp.

BOO-409: Seed Science and Technology - 4 Credits (3 Credit Theory: 45 hours + 1 Credit Practical: 15 sessions)

Objectives: To facilitate deeper understanding of various aspects of seed science and technology.

Pre-requisite: Basic knowledge of seed science at UG level.

Syllabus:

1. Concept of seed technology; seed quality, definition, importance and goals of seed technology; types of seed programmes; Steps involved in development of a seed programme. **(2L)**
2. **General Principals of seed production and Seed Processing:** genetic and agronomic principles; maintenance of nucleus seed; production of Breeder, Foundation and Certified seed; principles of seed processing; methods of seed drying. **(3L)**
3. **Seed cleaning equipment and their functions:** Preparing seed for processing; functions of Scalper, Debearder, Scarifier, Huller, Seed Cleaner and Grader. Screen cleaners, specific gravity separator, indented cylinder, velvet-spiral-disc separators, colour sorter, delinting machines; seed blending. **(4L)**
4. **Seed treatment:** Benefits, types of seed treatment, seed treating formulations and equipments, seed disinfestations, identification of treated seeds; packaging: principles, practices and materials; bagging and labeling. **(3L)**
5. **Seed storage:** Seed drying and storage; drying methods-importance and factors affecting it, changes during storage, concepts and significance of moisture equilibrium, methods of maintaining safe seed moisture content. Methods to minimize the loss of seed vigour and viability; factors influencing storage losses. Storage methods and godown sanitation. Storage structures. Storage problems of recalcitrant seeds and their conservation. **(5L)**
6. Seed germination and viability; Germination methods; TZ test; Embryo excision method. **(2L)**
7. **Seed Certification:** Objectives of seed certification; seed certification agency and staff requirement; legal status and phases of seed certification; formulation, revision and publication of seed certification standards; Indian Minimum Seed Certification Standards (General). **(4L)**
8. **Field Inspection:** objectives and general principles; Method of inspection; Post harvest inspection; specifications for tags and labels. **(3L)**
9. **Seed Legislation and Seed Law Enforcement:** Types of Seed legislation; Seed Legislation in India; Regulatory Legislations; Seed Law Enforcement; Seed Control Order, 1983; The Plant Varieties Act. **(4L)**

Practicals:

1. Identification of seeds of weeds and crops. **(1P)**
2. Physical purity analysis of samples of different crops. **(2P)**
3. Estimation of seed moisture content (oven method). **(1P)**
4. Seed dormancy breaking methods requirements for conducting germination test. **(1P)**
5. Seed germination testing in different agri-horticultural crops. **(2P)**

6. Viability testing by tetrazolium test in different crops. **(1P)**
7. Seed and seedling vigour tests. **(2P)**
8. Effect of drying temperature and duration on seed germination. **(2P)**
9. Testing coated/pelleted seeds. **(1P)**
10. Study of orthodox, intermediary and recalcitrant seeds. **(1P)**
11. Global seed germplasm resources and their conservation. **(1P)**

Reference Books:

Agarwal R.L. 2007. Seed Technology. Oxford & IBH.

Agrawal P.K. and Dadlani M. 1992. Techniques in Seed Science and Technology. 2nd Ed. South Asian Publications.

Agrawal P.K. 1993. Handbook of Seed Testing. Ministry of Agriculture, GOI, New Delhi.

Copland L.O. and McDonald M.B. 1996. Principles of Seed Science and Technology. Kluwer.

ISTA 2006. Seed Testing Manual. ISTA, Switzerland.

Martin C. and Barkley D. 1961. Seed Identification Manual. Oxford & IBH.

Tunwar N.S. and Singh S.V. 1988. Indian Minimum Seed Certification Standards. Central Seed Certification Board, Ministry of Agriculture, New Delhi.

BOO-410: Marine Phytoplankton – 1 Credit (1 Credit Theory: 15 hours)

Objectives: Microalgae can be identified only after preservation. Each algal group has different preparatory technique required for its basic identification with light microscope. This paper introduces these techniques, along with general characteristics, taxonomy, ecological and economic importance.

Pre-requisite: Knowledge of marine micro algae.

Syllabus:

1. Introduction and historical background**,** General characteristics, Taxonomy, collection preservation and preparation techniques and their importance for following groups. **(1L)**
2. **Marine Diatoms:** General characteristics, Life cycle, Morphology and terminology with respect to centric and pennate diatom. Collection preservation and preparation techniques. **(5L)**
3. **Marine Dino-flagellates:** General characteristics, Morphology and terminology, Microanatomy, Taxonomy and preparation techniques. **(4L)**
4. **Planktonic Micro-flagellates:** Chromophyta --Cryptophyta and Raphidophyta, Chrysophyta and Dictychophyceae, Prymnesiophyceae- Haptophyceae, Chlorophyta, Coccolithophorids. **(5L)**

Reference Books:

Fritsch, F.E. (1935). The Structure and Reproduction of the Algae. Cambridge University Press.

Hallegraeff, G.A. (1993). A review of harmful algal blooms and their apparent global increase. Phycologia 32, 79-99.

Hallegraeff, G.M., Anderson, D. M. and Cembella, A.D. (2003). Manual on Harmful Marine Micro-algae. UNESCO.

Hargraves, P.E. and French, F.W. (1983). Diatom resting spores: Significance and strategies. In: Fryxell, G. A. (Ed.), Survival Strategies of the Algae. pp. 49-68. Cambridge: Cambridge University Press.

BOO- 411: Ecotourism 4 credits (2 Theory: 30 hours + 2 Practical: 30 sessions)

Objectives: To make the students to opt various ecotourism programmes as a self employment stream; to make the students to aware about the usefulness of ecotourism in the conservation of natural resources, and to help the students to assess various ecotourism programmes.

Pre-requisite:

Syllabus:

1. **Eco-tourism:** Definition, concept, introduction, history, relevance and scope. **(2L)**
2. **Key Principles and Characteristics of Ecotourism**: Nature area focus, interpretation, environmental sustainability practice, contribution to conservation, benefiting local communities, cultural respect, customer satisfaction, responsible marketing. **(2L)**
3. **Components of Ecotourism:** Travel, tourism industry, biodiversity, local people, cultural diversity, resources, environmental awareness, interpretation, stake holders, capacity building in ecotourism. **(4L)**
4. **Eco Tourism Terms**: Adventure tourism, certification, commercialization chain, cultural tourism, canopy walkway, conservation enterprises, ecosystem, ecotourism activities, ecotourism product, ecotourism resources, ecotourism services, endemism, ecolabelling, ecotourism "lite", geotourism, greenwashing, stakeholders, sustainable development, sustainable tourism, leakages. **(4L)**
5. **Ecotourism resources in India and Goa**: Major ecosystems, vegetation types, biodiversity and tourism areas in Goa. Festivals and events, entertainment overview, culture, famous destinations, sightseeing, historical monuments, museums, temples, national parks & wildlife sanctuaries, hill stations, waterfalls, rivers, lakes, beaches, islands, mangroves, backwaters, wildlife watching and bird watching sites, agricultural sites, tribal areas, tribal museums, tribal arts, rural handicrafts, tribal medicines, archeological sites, adventure sports, sacred groves, mountains, etc. **(8L)**
6. **Forms of Ecotourism in India, western ghats and Goa**: Eco regions, eco places, western ghats of Goa, waterfalls in Goa and India, eco travel, dos and don't on eco travel, eco trips. Potentials of ecotourism in Goa. Community based ecotourism, ecotourism and NGOs. **(4L)**
7. **Ecotourism Planning**: Background, objectives, strategy, design of activities, target groups, opportunities, capacity building, threats, expectations positive and negative impacts, strength and weakness, benefits and beneficiaries, stakeholders, linkages, economics, ecotourism auditing. Problems with ecotourism. Carrying capacity of ecotourism. ecotourism facilities – Green report card. Ecotourism management – issues. **(4L)**
8. **Ecotourism and livelihood security:** Community, biodiversity conservation and development – Eco-development committees. **(2L)**

Practicals, field and work experience:

Lab sessions/demos would account for 5-10 hours and would be recorded in a standard format in a journal.

Specific to theory field trips would be held outdoors in nearby natural areas in association with ecotourism tour operators, Wildernest eco resort and sea eagle navigation; Goa tourism

development corporation, Wildlife and ecotourism wing of Goa forest department, Goa state biodiversity board, tourism and travel association of Goa, Youth Hostels association of India (Goa), Goa hiking association and other NGOs.
Work experience of 10-15 hours would be essential preferably at Wildernest ecotel-Sattari. Work experience report accounting for 10-15 hours to be certified by the mentoring ecotourism facility

-Besides the following would be essential in full or part accounting for 10-15 hours.
- Report on existing Ecotourism project appraisal selected by the students.
- Submission of a short new ecotourism project proposal in a standard format.
- A thematic photographic portfolio on ecotourism comprising student's original work.
- A thematic original short Video film of not more than 3-5 minutes duration on ecotourism.
- Designing of a website or a blog on ecotourism themes.
- Designing of an artistic publicity brochure on ecotourism theme.

Reference Books:

A K Bhattacharya. 2005. Ecotourism and Livelihoods. Concept Publ. Company, New Delhi.

Kreg Lindberg, Deonal E. Hawkins. 1999. Ecotourism: A guide for Planners and Managers. Natraj Publishers, Dehradun.

Batta, A. 2000. Tourism and environment. Indus Publishing Co., New Delhi.

Cater, E. 1994. Ecotourism in the third world: Problems and prospects for sustainability.

Cater and G. Lowman (Ed.). Ecotourism: a sustainable option, Wiley, Chichester.

Croall, J. 1995. Preserve or Destroy: Tourism and Environment, Calouste Gulbenkian Foundation, London.

BOO - 412: Advances in Mycology: Taxonomy, Biology and Application of Fungi - **3 Credits (2 Theory: 30 hours + 1 Practicals: 15 sessions)**

Objectives: The aim of this paper is to embody students of botany and allied biological subjects with recent understanding on diversity, taxonomy, biology and application of fungi in human welfare. Methods used to study the diversity, morphology and fungal taxonomy will be taught. The paper covers briefly the interaction and influences of fungi in various ecological set-ups, viz. terrestrial (soil, coprophilous, entomogenous and endophytes) and aquatic (marine and freshwater) habitats, with emphasis on decomposition of organic matter, involvement of enzymes, lichen biology and mycorrhizae. Fungal diseases on plants (plant pathology) and animals including humans (mycoses) and their management will be taught. The importance of fungi in agriculture, food, pharma-sector and industry will be covered.

Pre-requisite: Basic knowledge of microbes at UG level.

Syllabus:

1. **Introduction to fungi:** General characteristics; Morphology; Fungal mycelia and spores; Reproduction: sexual and asexual. **(2L)**
2. **Fungal diversity and classification**; Taxonomy and nomenclature; Use of morphology and molecular sequence data in taxonomy. Fungal phylogeny; Post-Melbourne IBC-2011 Rulings on mycology **(2L).**
3. **Fungi-like lower organisms (Pseudo-fungi):** Slime moulds; Oomycota; Straminofilan fungi. **(2L)**
4. **True lower-fungi:** Chytrids (Water-moulds); Zygomycota (Bread-moulds); Glomeromycota (endo-mycorrhizae). **(2L)**
5. **Ascomycota:** Whole fungus; Dikaryotic hyphae; Anamorph (asexual state) and teleomorph (sexual state); Unitunicate and bitunicate fungi; Conidium ontogeny; Yeasts; Lichens; Powdery mildews; Dothedian fungi **(4L)**
6. **Basidiomycota:** Mushrooms, puff-balls, rusts and smuts; yeast-like fungi. **(3L)**
7. **Mutualistic fungi:** Ecto- and endo-mycorrhizae. **(1L)**
8. **Fungi and Plant diseases:** infection process; symptoms; epidemiology; vertical and horizontal resistance; major crop diseases. **(3L)**
9. **Fungi in different habitats:** Terrestrial fungi (soil, coprophilous, litter, entomogenous, foliicolous and endophytes); Aquatic fungi (Marine, manglicolous and Freshwater) **(3L)**
10. **Fungal Ecology:** Bio-deterioration; Decomposition of organic matter; Fungal enzymes. **(2L)**
11. **Medical mycology:** Mycoses (superficial, subcutaneous and systemic infections); Immune-deficiency. **(2L)**
12. **Application of Fungi:** In food, medicine, biofertilizer, biopesticide and bioremediation. **(3L)**
13. Revision of topics. **(1L)**

Practicals: (**One credit: 15 sessions)**

1. Collection and study of samples of fungi of different classes; recording field data; preparation of fungal herbarium. **(2L)**
2. Microscopic study and understanding of fungi on plant litter; use of different stains in observation of fungi. **(1L)**
3. Single spore isolation; use of natural, semi-synthetic and synthetic media. Isolation of pure cultures of fungi from diverse samples and their characterization. **(2L)**
4. Photomicrography of fungi, digital image analysis, taxonomic drawings using drawing tube. **(1L)**
5. Use of taxonomic keys and electronic databases in identifying fungi; writing taxonomic description in mycology. **(1L)**
6. Extraction of fungal DNA, RNA, Proteins; RAPD of fungal cultures. **(2L)**
7. Studying holomorphs (sexual and asexual state physical connection) in the lab. **(2L)**
8. Study of fungi from aquatic, coprophilous, endophytic, plant-pathogenic, soil habitats; examination of samples of fungal human pathogens**. (3L)**
10. Study of fungal enzymes **(1L)**

Reference Books:

Kendrick, B. (2003). The Fifth Kingdom, Mycology Publications.

Booth, C. (1971). Methods in Microbiology, Volume 4, Academic Press.

Berry D. R. (1988). Physiology of industrial Fungi, Blackwell Scientific Publishers.

Bridge, P.D. (1998). Applications of PCR in Mycology, CABI, UK.

Nair, L.N. (2007). Topics in Mycology and Pathology. New central Book agency, Kolkata.

Sundar Rajan, S. (2000). Practical Manual of Fungi, Anmol Publications, New Delhi.

Koneman, E.W. and G.W. Roberts. (1985).Practical laboratory Mycology, Williams and Wilkins.

Hawksworth, D.L. (1974). Plant pathologist's pocketbook, CAB, UK.

Evans, E.G.V. and M.D. Richardson. (1989). Medical Mycology : A practical approach, IRL Press.

Manuel A. S. Graça, Felix Bärlocher and Mark O. Gessner. (2005). Methods to study litter decomposition: a practical guide, Springer.

Hawksworth, D. L., P. M. Kirk, B. C. Sutton and D. N. Pegler. (2005). Ainsworth and Bisby's Dictionary of the fungi, 8th edition, CAB international.

Bhat, D.J. (2010). Fascinating Microfungi (hyphomycetes) of Western Ghats-India, Broadway Book Centre, Goa.

Sathe A. V., Deshpande S. , Kulkarni, S. M. and J. Daniel. (1980). Agaricales (mushrooms) of south-west India. MACS, Pune.

DISSERTATION

Total: 12 Credits (This is in lieu of optional courses equivalent to 12 credits)

Duration: III & IV Semester

Should be carried out under the guidance of a Teacher.
