M.Sc. Botany Programme

(Choice Based Credit System- 64 Credits)

Course Structure

Course Number	Course Title	Credits
(CORE COURSES)		
BOC-121	Algae, Bryophytes, Pteridophytes and Gymnosperms	3
BOC-122	Lab in Algae, Bryophytes, Pteridophytes and Gymnosperms	1
BOC-123	Plant Microbiology and Pathology	3
BOC-124	Lab in Plant Microbiology and Pathology	1
BOC-125	Systematics of Angiosperms	3
BOC-126	Lab in Systematics of Angiosperms	1
BOC-221	Internal Morphology and Developmental Biology of Angiosperms.	3
BOC-222	Lab in Internal Morphology and Developmental Biology of Angiosperms	1
BOC-225	Plant Physiology	3
BOC-226	Lab in Plant Physiology	1
BOC-321	Plant Molecular Biology	3
BOC-323	Plant Genetic Engineering	3
BOC-324	Lab in Plant Molecular Biology and Genetic Engineering	2
BOC-421	Cytogenetics and Plant Breeding	3
BOC-422	Lab in Cytogenetics and Plant Breeding	1
(OPTIONAL COURSES) A student must choose **at least 16 credits** from the following		
BOO-121	Techniques and Instrumentation in Botany	3
BOO-122	Lab in Techniques and Instrumentation in Botany	1
BOO-123	Bioinformatics	2
BOO-124	Lab in Bioinformatics	1
BOO-125	Oenology (Wine Science and Technology)	1
BOO-126	Lab in Oenology (Wine Science and Technology)	1
BOO-127	Mine wasteland Management	2
BOO-128	Seed Science and Technology	2
BOO-129	Lab in seed Science and technology	1
BOO-221	Plant animal Interaction	4
BOO-224	Post Harvest Technology for Fruit Crops	2
BOO-225	Ethnobotany	2
BOO-226	Remote sensing: Techniques and applications	2
BOO-227	Lab in Remote sensing: Techniques and applications	1
BOO-329	Applied Phycology: Utilization and Management	3
BOO-322	Plant Biotechnology	3
BOO-323	Lab in Plant Biotechnology	1
BOO-324	Mycorrhizal Biotechnology	2

BOO-325	Lab in Mycorrhizal Biotechnology	1
BOO-326	Plant Histochemistry	2
BOO-327	Lab in Plant Histochemistry	1
BOO-328	Introduction to Paleoflora	1
BOO-436	Marine Phytoplanktons	1
BOO-440	Bioentrepreneurship and Innovation	1
BOO-441	Lab in Bioentrepreneurship and Innovation	1
BOO-442	Mushroom biotechnology	1
BOO-443	Lab in Mushroom biotechnology	1
BOO-447	Ecotourism	2
BOO-448	Lab in Ecotourism	2
BOO-449	Advanced Ecology	3
BOO-450	Lab in Advanced Ecology	1
BOO-451	Plant Biochemistry	3
BOO-452	Lab in Plant Biochemistry	1
BOO-453	Introduction to Omics	3
BOO-501	Fungal Chemistry and Mycoremediation	1
BOO-502	Lab in Fungal Chemistry and Mycoremediation	1
BOO-503	Glycobiology	1
BOO-504	Lab in Glycobiology	1
BOO-505	Fungal Biodiversity, Bioprospecting and Biotechnology	3
BOO-506	Lab in Fungal Biodiversity, Bioprospecting and Biotechnology	1
BOO-507	Mycological Techniques	3
BOO-508	Lab in Mycological Techniques	1
BO-DISS	**Dissertation**	8

Programme: M. Sc. (Botany)
Course Code: BOC-121
Title of the Course: Algae, Bryophytes, Pteridophytes and Gymnosperms.
Number of Credits: 3
Effective from AY: 2020-21

Prerequisites for the course:	Should have studied B. Sc. Botany.	
Objective:	To study general characteristics, classification, trends in classification, phylogeny and inter-relationships of Algae, Bryophyta, Pteridophyta and Gymnosperms.	
Content:	**1. Algae:** General introduction to algae: Classification of Algae; Recent trends in the classification of Algae; General account of morphology, anatomy, reproduction, life histories, classification, phylogeny and inter-relationship, ecological and economic importance of the following groups: Chlorophyta, Charophyta, Chrysophyta, Cryptophyta, Pyrrhophyta, Phaeophyta and Rhodophyta **2. Bryophyta:** Introduction to Bryophyta: General characteristics, classification; Distribution, morphological, anatomical , reproductive studies and comparative account of sporophytes and gametophytes and interrelationships of the following groups: **Hepaticae:** Sphaerocarpales, Calobryales,Takkakiales, Marchantiales, Jungermanniales, **Anthoceotae**: Anthocerotales; **Musci:** Spagnales, Andaeales, Polytrichales, Buxbaumiales Funariales including their fossil relatives **3. Pteridophyta:** General characters and classification of Pteridophytes; Comparative account of Psilophyta. Lycophyta, Eqisetophyta and Flicophyta; Aposory and Apogamy, Heterospory, Soral Evolution, Fossil Pteridophytes **4. Gymnosperms:** General characters and Classification of Gymnosperms; Comparative account of Morphology, anatomy, phylogeny and interrelationships of Pro-Gymnospermopsida, Gymnospermopsida, Gnetopsida and Fossil Gymnosperms.	**9 hours** **9 hours** **9 hours** **9 hours**
Pedagogy:	Lectures/ Tutorials/Assignments/Self-Study	
References/Readings	**1. Agashe, S. N.** (1995). Paleobotany, Oxford and IBH Publ. Co. Pvt. Ltd, New Delhi. **2. Arnold, A. C.** (2005). An Introduction to Paleobotany, Agrobios (India), Jodhpur. **3. Bhatnagar S. P. and Moitra A.** (1996). Gymnosperms. New Age International, New Delhi. **4. Biswas C. and Johri B. M.** (1997). Gymnosperms.	

Narosa Publishers, NewDelhi.
5. Bold H.C. and Wynne M. J. (1985). Introduction to the algae; Structure and reproduction. Prentice Hall, Englewood cliffs, New Jersey.
6. Cavers, F. (1976). The inter relationships of the bryophyte. S.R. Technic, **Ashok Rajpath**, Patna.
7. Chapman V.J. and Chapman D.J. (1975). The algae, 2nd Edition, Mac. Millan Publ. Inc. New York.
8. Chopra, R. N., and Kumar P. K. (1988). Biology of Bryophytes. John Wiley and Sons, New York, NY.
9. Desikachary, T.V. (1959). Cyanophyta ICAR, New Delhi
10. Hoek, C. van den, Mann, D. G. and Jahns, H. M. (1995). Algae: An introduction to Phycology, CambridgeUniversity Press, UK.
11. Kashyap, Shiv Ram (1929). Liverworts Of The Western Himalayas And The Punjab PlainPart 1 Chronica Botanica, New Delhi.
12. Kashyap, Shiv Ram, (1932). Liverworts of the western Himalayas and the panjab plain (illustrated): Part 2. The Chronica Botanica New Delhi.
13. Parihar, N.S. (1976). Biology and morphology of the Pteidophytes. Central Book Depot.
14. Parihar, N. S. (1980). Bryophytes: An introduction to Embryophyta Vol I Bryophyta.Central Book Depot.
15. Prem Puri (1981). Bryophytes: Morphology, Growth and Differentiation, Atmaram and Sons, New Delhi.
16. Prescott G. W. (1969). The algae: A review. Nelson, London.
17. Rashid, A. (1999). An Introduction to Pteridophyta, Vikas Publishing House Pvt. Ltd., New Delhi.
17. Ramanujan, C.K.G. (1970). Indian Gymnosperms in time and space. Today & Tomorrow's Printers & Publishers.
18. Round, F.E. (1981). The Ecology of Algae, Cambridge University Press, Cambridge.
19. Sharma, O.P. (1990). Textbook of Pteridophyta. Macmillan India Ltd., Delhi.
20. Singh, V. P. (2006). Gymnosperms (Naked seed plants): Structure and Development, Sarup and Sons, New Delhi.
21. Sporne, K.R. (1965), Morphology of Gymnosperms Hutchinson University Library.
22. Sporne, K.R. (1986). The morphology of Pteridophytes. Hutchinson University Press, London,

	23. Smith, G. M. (1995). The fresh water Algae of the United States, Mc-Graw Hill, New York. **24. Srinivasan, K. S**. (1969). Phycologia India. Vol I & Vol II B.S.I., Calcutta. **25. Surange, K.R.** (1966). Indian fossil Pteridophytes Council of Scientific and Industrial research. New Delhi. **26. Sundara Rajan, S.** (1999). Introduction to Pteridophyta. New Age International Publishers, New Delhi. **27. Trainor, F.R.** (1978). Introductory Phycology, Wiley & Sons. New York. **28. Udar, Ram,** (1975). Bryology in India: Chronica Botanica, New Delhi. **29. Udar, Ram,**(1970). Introduction Bryophyta Shashidhar Malaviya Prakashan, Lucknow. **30. Vashishta B.R.** (1988). Algae. S. Chand & Co., New Delhi. **31. Waston E. V**. (1971). Structure and life of Bryophytes 3rd Hutchinson University Library, London.	
Learning Outcomes	1. Students will have clear idea of the characteristics of the important plant groups taught in this paper. 2. Concepts in the evolution of plants will be clear to students.	

Programme: M. Sc. (Botany)
Course Code: BOC-122
Title of the Course: Lab in Algae, Bryophytes, Pteridophytes and Gymnosperms.
Number of Credits: 1
Effective from AY: 2020-21

Prerequisites for the course:	Should have studied B. Sc. Botany.	
Objective:	To introduce and expose the students to skills required in field and lab based on theory.	

Content:	**1.** Study of vegetative and reproductive features of important algal groups with the available representatives; Chlorophyta, Charophyta, Euglenophyta, Chrysophyta, Cryprtophyta, Pyrrhophyta, Phaeophyta, and Rhodophyta. **2.** Study of vegetative and reproductive features of important bryophytesgroups with the available representatives -Hepaticae, Anthocerotae and Musci. **3.** 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 **4.** Vegetative and reproductive features of Gymnospermopsida and Gnetopsida with available representatives.	**8 hours** **6 hours** **6 hours** **4 hours**
Pedagogy:	Conducting Practicals mostly with freshly collected and herbarium specimens, field visits, demonstrations, small projects,*etc.*	
References/Readings	**1. Biswas C. and Johri B. M.** (1997). Gymnosperms. Narosa Publishers, NewDelhi. **2. Bold H.C. and Wynne M. J.** (1985). Introduction to the algae; Structure and reproduction. Prentice Hall, Englewood cliffs, New Jersey. **3. Desikachary, T.V.** (1959). Cyanophyta ICAR, New Delhi. **4. Parihar, N.S.** (1976). Biology and morphology of the Pteidophytes Central Book Depot. **5. Parihar, N. S.** (1980). Bryophytes: An introduction to Embryophyta Vol I Bryophyta central Book Depot. **6. Prem Puri** (1981). Bryophytes: Morphology, Growth and Differentiation, Atmaram and Sons, New Delhi. **7. Prescott G. W**. (1969). The algae: A review. Nelson, London. **8**. **Rashid, A.** (1999). An Introduction to Pteridophyta, Vikas Publishing House Pvt. Ltd. New Delhi. **9. Ramanujan, C.K.G.** (1970). Indian Gymnosperms in time and space. Today & Tomorrow's Printers & Publishers. **10. Sporne, K.R.** (1986). The morphology of Pteridophytes. Hutchinson University Press. London **11. Smith, G. M.** (1995). The fresh water Algae of the United States, Mc-Graw Hill, New york. **12. Srinivasan, K. S**. (1969). Phycologia India. Vol I &Vol II B.S.I. Calcutta. **13. Vashishta B.R.** (1988). Algae. S. Chand & Co., New	

	Delhi. **14. Waston E. V**. (1971). Structure and life of Bryophytes 3rd Hutchinson University Library London.	
Learning Outcomes	1. Able to understand technical description of plants and construct and use keys for identification.morphological, anatomical and reproductive characteristics of the respective plant groups. 2. Able to understand the concepts of the plant evolution. 3. Overall they will have better understanding in area of plant diversity and will beable to carry out research work in this field.	

Programme: M. Sc. (Botany)
Course Code: BOC-123
Title of the Course: Plant Microbiology and Pathology.
Number of Credits: 3
Effective from AY: 2020-21

Prerequisites for the course:	Knowledge of basic microbiology-bacteria, viruses, fungi and plant pathogens at UG level.	
Objective:	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 theircontrol practices	

Content:	**1. General Introduction:** Plant microbe interactions in health and diseases and the changing picture due to climate change	**1hour**
	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.	**4 hours**
	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.	**4 hours**
	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.	**4 hours**
	5. Study of different groups of fungi with suitable native examples: Slime moulds, Chytridiomycota; Ooomycota; Glomeromycota; Zygomycota; Ascomycota and Basidiomycota; Straminopile fungi.	**11 hours**
	6. Economic and biotechnological dimension of fungi: Study of economic importance of fungi; Endo- and ecto-mycorrhizae; Orchid mycorrhizae; Edible and	**12 hours**

	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. 7. **Tropical Plant Pathology:** Diseases of plants in the tropics and their systematic studies using modern techniques. A brief history of plant pathology in India. Symptomatology in fungal, bacterial, viral and mycoplasma diseases of plants; Obligate and facultative pathogens. Classification of plant diseases; methods in the study of plant diseases; Koch postulates; Principles of infection and spread of disease; Sources of inoculum; Physiology of host-pathogen interaction; Role of enzymes and toxins in pathogenesis; Molecular basis of plant diseases; 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.	
Pedagogy:	Lectures/ Tutorials/Assignments/Seminars/Moodle Based Work/Videos/Self-Study	
References/Readings	1. **Atlas, M. and Bartha, R.** (2000). Microbial Ecology, Longmann, New York. 2. **Black, J. G.** (1999). Microbiology–Principles and Explorations, Prentice Hall, London. 3. **Brock, T. D.** (1996). Biology of microorganisms Prentice Hall, London. 4. **Casida, L. E.** (1997). Industrial microbiology. New Age Publishers, New Delhi. 5. **Dubey, R. C. and Maheswari, D. K.** (2010). A Text book of Microbiology, S.Chand& Company, New Delhi.	

6. **Gerald Karp** (2008). Cell and Molecular biology-concepts and experiments. John Wiley & Sons, New York.
7. **Kumar, H. D. and Swati Kumar** (1999). Modern concepts of Microbiology, Vikas Publishing House, New Delhi.
8. **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.
9. **Pelezar, M.J., Chan,E.C.S and Kreig,N.R.**(1993).Microbiology-concepts and Applications. McGraw Hill, Inc. New York.
10. **Powar, C.B. and Daginawala,H.F.**(1982).General Microbiology Vol.II.Himalaya Publishers,Bombay.
11. **Rao,A.S.**(2001).Introduction to Microbiology. Prentice Hall of India, New Delhi.
12. **Ainsworth,G.C., Sparrow, F. K. and Sussman, A. S.** (1973). The Fungi. Academic Press, New York.
13. **Alexopoulose, C.J., Mims,C.W., Blackwell,M.** (1996).Introductory Mycology. John Wiley & Sons, New York.
14. **Bessy, E.A.** (1979).Morphology and Taxonomy of Fungi.Vikas Publishing House, New Delhi.
15. **Burnett,J.H.** (1968).Fundamentals of Mycology.Edward Arnold Ltd. London.
16. **Chopra, G.L.** (1998). A text book of Fungi.S.Nagin&Co. Meerut.
17. **Dube, H.C.** (1996). An Introduction to Fungi.Vikas Publish.House, New Delhi.
18. **ElizabethMoore-Landeeker**(1996).Fundamentals of Fungi.Prentice Hall, New Jersey.
19. **Hale, M.E.** (1983).Biology of Lichens. Edward Arnold, London.
20. **Hudson, H. J.**(1986). Fungal Biology. Edward Arnold, London.
21. **Mehrothra, R.S. and Aneja,K.R.** (1990).An Introduction to Mycology. Wiley Eastern Ltd. New Delhi.
22. **Sharma, O.P.** (2007).Text book of Fungi. Tata McGraw Hill, Publishing Co. Ltd. New Delhi.
23. **Sharma, P.D.** (2004).The Fungi for University students.Rastogi Publications, Meerut.
24. **Srivastava, J.P.** (1998). Introduction to Fungi. Central Book Depot, Allahabad.
25. **Sumbali, G.** (2005).The Fungi.Narosa Publishing House, New Delhi.

	26. Agrios, G.N. (1997).Plant Pathology. Academic Press, New Delhi. **27. Bilgrami, K.S. and Dube, H. C.** (1990).A text book of Modern Plant Pathology. Vikas Publishing House, New Delhi. **28. Butler,E.J. and Jones, S. G.** (1949).PlantPathology. Mc Millan, London. **29. Chatterjee,P.B.** (1997).Plant Protection Techniques.Bharati Bhavan, Patna. **30. Chattopadhayay, S.B.** (1991).Principles and Procedures of Plant Protection. Oxford &IBH, New Delhi. **31. Manners, J.G.** (1982).Principles of Plant Pathology.Cambridge University Press, London. **32. Marshall, H.** (1999). Diseases of Plants.Anmol Publications Pvt. Ltd. New Delhi. **33. Mehrotra, R. S.** (2000). Plant Pathology. Tata McGraw Hill, Publishing Co.Ltd. New Delhi. **34. Mundkur,B.B.** (1982). Text Book of Plant Diseases. Macmillan India Ltd., New Delhi. **35. Pathak, V. N.,Khatri, N. K. and Pathak,M.** (1996).Fundamentals of Plant Pathology. Agrobotanical Publishers (India), Bikaner. **36. Rangaswamy, G. and Mahadevan, A.** (2002). Diseases of Crop Plants in India. Prentice Hall of India, New Delhi. **37. Sharma,P.D.** (2005).Plant Pathology.Narosa Publishing House, New Delhi. **38. Singh,R.S.** (2000). Introduction to the Principles of Plant Pathology. Oxford IBH, New Delhi	
Learning Outcomes	1. Be able to identify microbial habitats and plant disease symptoms. 2. Be able to work in a field laboratory for mycological studies. 3. Gain better understanding of tropical microbial biodiversity and their ecological roles. 4. Have better prospects as plant pathologist in various farms.	

Programme: M. Sc. (Botany)
Course Code: BOC-124
Title of the Course: Lab in Plant Microbiology and Pathology
Number of Credits: 1 (Total sessions 24 hours)
Effective from AY: 2020-21

Prerequisites for the course:	Basic knowledge of microbial habitats in a tropical setup and general idea of diseases affecting crops.	
Objective:	To impart requisite field and lab skills in plant microbiology and pathology with emphasis on tropical strains and local needs in agriculture and economy dealing with economically important microbes.	
Content:	**1**. Microbial ecology in relation to the plants-Introduction to field techniques to studyplant-microbe interactions. **2**. Isolation and maintenance of pure cultures using common microbiological media. **3.** Phylloplane microflora- visualization and isolation. **4**. Rhizosphere microflora- visualization and isolation. **5.** Use of Microscopy in studying microbes in detail - preparation of unstained and stainedspecimens of eubacteria, actinobacteria. **6.** Preparation of unstained and stained specimens of yeasts, fungi. **7.** Examination of gram character of bacteria. **8.** Photomicrography and digital image analysis of representative pure cultures andinterpretation of results. **9.** SEM study of plant viruses using electron dense stains. **10.** Studying Phylogeny of plant viruses using bioinformatics tools. **11.** Study of root nodulation, symbiosome, Nitrogen fixing*Rhizobium*, leghemoglobin and Quorum Sensing in bacterial population. **12**. Methods of isolation and culturing of fungi: colony characters; microscopic observations; morphology of hyphae and spores. **13.** Study of reproductive structures of different genera of fungi. **14.** Study of fungal physiology in pure colonies – characterization of fungal colonies. **15.** Microfluidics in mycology- fabrication and applicationof microfluidics devices to fungalcultures for realtime visualization of fungal metabolic activities. **16.** Introduction to mycological databases and mycosystematics on Internet. **17.** Introduction to Mycobioinformatics- tools and	**Except 25-27 All 2 hour sessions**

	techniques (exercise to construct fungalphylogenetic tree to be given). **18.** Observation of different fungal substrates using sterile moist chamber incubation (*e.g.*herbivore dung; decomposing leaf-litter). **19.** Observations on ecological succession of fungi; Terrestrial, marine and freshwater fungi. **20**. Particle-plating technique for isolation of litter fungi. **21**. Technique for isolation of fungal endophytes. **22.** Isolation and serial dilution techniques (*e.g.* soil, dung and leaf litter). **23.** Collection of infected specimens in the field and observation of symptoms. **24.** Hand sections and tease mounts from infected plant specimens. **25.** Study of as many as possible viral, bacterial and fungal diseases of crop plants (cereal, vegetable, fruit, and plantations) from surrounding habitats in Goa. **26.** Submission of 10 dried herbarium specimens of infected plant materials [fungal (4) +bacterial (3) + viral (3)] collected from nearby habitats. **27.** A mini field project to study crop diseases from field and market specimens.	
Pedagogy:	Field visits and lab exercises/sample collections/use of electronic, digital and visual keys, herbarium production/videos/moodle guided exercises/mini projects/demonstration.	
References/Readings	1. **Sharma, P.D.** (2004).The Fungi for University students.Rastogi Publications, Meerut. 2. **Srivastava,J.P.** (1998).Introduction to Fungi. Central Book Depot, Allahabad. 3. **Sumbali,G.** (2005).The Fungi.Narosa Publishing House, New Delhi. 4. **Agrios, G.N.** (1997).Plant Pathology. Academic Press, New Delhi. 5. **Bilgrami,K.S. and Dube, H. C.** (1990).A text book of Modern Plant Pathology. Vikas Publishing House, New Delhi. 6. **Butler,E.J. and Jones, S. G.** (1949).PlantPathology. Mc Millan,London. 7. **Chatterjee,P.B.** (1997).Plant Protection Techniques.Bharati Bhavan, Patna. 8. **Chattopadhayay,S.B.** (1991).Principles and Procedures of Plant Protection. Oxford &IBH, New Delhi.	
Learning Outcomes	1.Ability to work as a field microbiologist to sample	

	various habitats and asplant pathologist being able to identify disease symptoms 2.Being able to identify common micro and macrofungi from diverse natural habitats 3.Being able to prepare herbarium of diseased plants 4.Being able to isolate and manage microbial cultures 5.Being able to do photomicrography and image analysis of cultures 6.Being able to apply techniques learnt in appropriate projects involving economically important microbes	

Programme: M. Sc. (Botany)
Course Code: BOC-125
Title of the Course: Systematics of Angiosperms.
Number of Credits: 3
Effective from AY: 2020-21

Prerequisites for the course:	Should have studied Plant Taxonomy at undergraduate level. They should be good in basics of classification and nomenclature of angiosperms.	
Objective:	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 sources 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 and applications.	
Content:	1. **Plant taxonomy**: Scope and importance; taxonomy as a synthetic discipline; principles and goals; applications - IUCN Red List, Conservation priorities. 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. 3. **Nomenclature:** Purpose, Principles, and overall knowledge of International Code of Nomenclature for algae, fungi, and plants (ICN) and Articles pertaining to typification, publication, priority, author citation and their application. 4. **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	**4 Hours** **6 Hours** **7 Hours** **9 Hours**

	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. 5. **Phylogeny and Classification of Angiosperms:** Fossil angiosperms and their ecology. APG IV system of classification of angiosperms; characteristics and phylogeny of clades: Orders – Amborellales, Nymphaeales, Austrobaileyales, Chloranthales; Clades (Magnoliids), (Monocots (Commelenids)), Order Ceratophyllales, (eudicots ((superrosids (Rosids (malvids, fabids))) (Superasterids (asterids (campanulids, lamids))))).	**10 Hours**
Pedagogy:	Lectures/ Tutorials/Assignments/Self-Study	
References/Readings	1) **APG IV,** 2016. An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants: APG IV, *Botanical Journal of the Linnean Society*, Volume 181, Issue 1, 1 May 2016, Pages 1–20, https://doi.org/10.1111/boj.12385 2) **Barry G. Hall,** 2011. Phylogenetic Trees Made Easy: A How-To Manual. Fourth Edition.Sinauer Associates, Inc., Publishers, Sunderland, USA (Now Oxford University Press). 3) **Benson, L.D.** 1962. Plant Taxonomy: Methods and Principles. Ronald Press, New York. 4) **Cronquist, A.** 1981. An Integrated System of Classification of Flowering Plants. Columbia University Press, New York. 5) **Davis, P.H. and V.M. Heywood.** 1963. Principles of Angiosperm Taxonomy. Oliver & Boyd, Edinburgh. 6) **Douglas Soltis, Pamela Soltis, Peter Endress, Mark Chase, Steven Manchester, Walter Judd, Lucas Majure, and Evgeny Mavrodiev,** 2017. Phylogeny and Evolution of Angiosperms (Revised and Updated edition). University of Chicago Press: 1427 E. 60th Street Chicago, IL 60637 USA. 7) **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.	

8) **Jain, S.K. and R.R. Rao.** 1977. A handbook of Field and Herbarium methods. Today and Tomorrow Printers and Publishers, New Delhi.
9) **Joesph Felsenstein,** 2003. Inferring Phylogenies. Sinauer Associates, Inc. (Now Oxford University Press).
10) **Jones, S.B. and A.E. Luchsinger.** 1987. Plant Systematics (2nd Ed.) McGrawHill Book Company. New York.
11) **Lawrence, G.H.M.** 1951. Taxonomy of Vascular. Plants. Oxford & IBH Publishing Co.
12) **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)
13) **Michael George Simpson,** 2010. Plant systematic (2nd Edition). Academic Press.
14) **Nei, M. and S. Kumar,** 2000. Molecular Evolution and Phylogenetics. Oxford University Press Inc.
15) **Peter Skelton and Andrew Smith,** 2002. Cladistics: A Practical Primer on CD-ROM with accompanying booklet by Neale Monks.Cambridge University Press.
16) **Stevens, P. F.** (2001 onwards). Angiosperm Phylogeny Website. Version 14, July 2017 [and more or less continuously updated since]. http://www.mobot.org/MOBOT/research/APweb/
17) **Quicke, D.L.J.** 1993. Principles and Techniques of Contemporary Taxonomy. Blackie Academic & Professional (An imprint of Chapman & Hall.).
18) **Radford, A.E., W.C. Dickinson, J.R. Massey and C.R. Bell,** 1974. Vascular Plant Systematics, Harper & Row, New York.
19) **Robert W. Scotland and Toby Pennington,** 2000. Homology and systematics: coding characters for phylogenetic analysis.Systematics Association.
20) **Salemi, M. and A.-M. Vandamme,** 2003.The Phylogenetic Handbook. A Practical Approach to DNA and Protein Phylogeny.Cambridge University Press.
21) **Singh, G.** 2010. Plant systematics: an integrated approach (Third Edition). CRC Press.
22) **Sivarajan, V.V.** 1991. (2nd ed.). Introduction to the Principles of Plant Taxonomy (Ed. N S K Robson). Oxford & IBH publishing Co. Pvt. Ltd.
23) **Stace, C.A.** 1989 (2^{nd} ed.). Plant Taxonomy and Biosystematics. Edward Arnold.
24) **Stuessy, Tod F.,** 2009. Plant taxonomy: the systematic evaluation of comparative data (2nd ed.). New York:

	Columbia University Press. 25) **Walter S. Judd, Christopher S. Campbell, Elizabeth A. Kellogg, Peter F. Stevens, Michael J. Donoghue,** 2015. Plant Systematics: A Phylogenetic Approach, Fourth Edition.Sinauer Associates, Inc., Publishers, Sunderland, USA (Now Oxford University Press).	
Learning Outcomes	1. Able to relate plant taxonomy to various other branches including conservation. 2. Should be in a position to understand and use Floras, Revisions and Monographs. 3. Should be able to apply nomenclatural rules. 4. Able to understand and interpret the phylogenetic trees. 5. Know the latest phylogenetic classification of angiosperms, relationships among major clades and their evolution.	

Programme: M. Sc. (Botany)
Course Code: BOC-126
Title of the Course: Lab in Systematics of Angiosperms
Number of Credits: 1
Effective from AY: 2020-21

Prerequisites for the course:	Should have studied or have the practical knowledge of Plant morphological terms.	
Objective:	To learn plant taxonomy through dissection of flowers, use of Floras and field study and develop skills to handle plant identification and floristic work independently and at the same time able to handle molecular data for interpreting phylogeny.	
Content:	1. Writing of technical descriptions. 2. Construction of keys. 3. Identification of local species using Floras, keys and campus field trips. 4. Identification of 25 families using diagnostic characters; diagnostic characters to be illustrated. 5. Construction of phylogentic tree based on gene sequences available at NCBI database (each student may be given different gene sequences/taxa).	**2 hours** **2 hours** **4 hours** **12 hours** **4 hours**
Pedagogy:	Through actual dissection of floral parts/ Field trip /Practice	

References/ Readings	1) **Barry G. Hall.** 2007. Phylogenetic Trees Made Easy: A How-To Manual, Third Edition. Sinauer Associates, Inc., Publishers, Sunderland, USA. 2) **Jain, S.K. and R.R. Rao.** 1977. A handbook of Field and Herbarium methods. Today and Tomorrow Printers and Publishers, New Delhi. 3) **Lawrence, G.H.M.** 1951. Taxonomy of Vascular. Plants. Oxford & IBH Publishing Co. 4) **Singh, G.** 2009. Plant systematics: an integrated approach. Science Pub Inc. 5) **Utteridge, T. and G. Bramley.** 2014. Tropical Plant Families Identification Handbook. Kew Publishing. 6) **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.	
Learning Outcomes	1. Able to write technical description of plants and construct and use keys for identification. 2. Able to identify common plant families based on the morphological features. 3. Able to recognise common plants. 4. Able to construct phylogenetic tree based on molecular sequences.	

Programme: M. Sc. (Botany)
Course Code: BOC-221
Title of the Course: Internal Morphology and Developmental Biology of Angiosperms.
Number of Credits: 3
Effective from AY: 2020-21

Prerequisites for the course:	Should have studied B. Sc. Botany. It is assumed that students have a basic knowledge of anatomy and developmental biology of higher plants.	
Objective:	The paper provides deeper understanding of various anatomical structures and their functions,several embryological processes including pollen pistil interaction, applied aspects of embryology, various palynological methods to understand pollen biology and pollen biotechnology of flowering plants.	
Content:	**Internal Morphology** **1. Meristems:** Shoot and root apical and intercalary meristems; their ultra-structure and histochemistry;	**3 hours**

	cytological and molecular analysis of the shoot apical meristem; autonomy of the meristem and vascular tissue differentiation in the shoot apex.	
	2. Vascular cambium vs cork cambium, factors controlling their activity; lenticels; abscission; wound healing.	**2 hours**
	3. Ontogeny, phylogeny, evolution, ultra-structure and function of primary and secondary xylem; wood anatomy; bio-deterioration of wood and its prevention.	**3 hours**
	4. Ontogeny, phylogeny, evolution, ultra-structure and function of primary and secondary phloem.	**2 hours**
	5. Structural variability in leaves including leaf structures of$C_3$and C_4sub-types, CAM plants; leaf histogenesis; leaf meristems; evolution of leaf forms, heteroblasty. Origin, development and ultra-structure of trichomes and stomata.	**3 hours**
	6. Nodal anatomy: Nodal types, phylogenetic and evolutionary considerations.	**1 hour**
	9. Anatomy of monocotyledonous and dicotyledonous seeds and fruits - their ontogeny structure and functions.	**2 hours**
	<u>Embryology</u>	**2 hours**
	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.	**2 hours**
	2. Megasporogenesis and formation of embryo sac: Ovule differentiation and development, megasporogenesis, organization of embryo sac, types of embryo sac, gene function during megagametogenesis.	**3 hours**
	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.	**3 hours**
	4. Endosperm and embryogenesis: Endosperm, embryo, nutrition and growth of embryo. Gene action during embryogenesis, storage compounds in endosperm and embryo, storage protein gene expression in transgenic systems; apomixis and polyembryony; applied aspects of embryology.	**3 hours**
	<u>Palynology</u>	
	1. Pollen Biology: Pollen morphological characters, Pollen wall features, pollen development and evolution of pollen types, palynology and taxonomy.	**2 hours** **2 hours**

	2.Aeropalynology: Methods of aerospora survey and analysis; pollen allergy and pollen calendars. **3. Mellittopalynology:** Honey bee and pollen loads; role of apiaries in crop production. **4. Palaeopalynology:** Study of fossil pollens and spores and their significance in paleobotany and coal and oil explorations. **5.**Pollen biotechnology for crop production and improvement.	**2 hours** **1 hour**
Pedagogy:	Lectures/ Tutorials/Assignments/Seminars/Self-Study	
References/Readings	1. **Shivanna, K. R. and Rangaswamy N. S.**1992. Pollen Biology - A Laboratory Manual, Narosa Publishing House, New Delhi. 2. **Batygina T. B.**2009. Embryology of Flowering Plants Terminology and Concepts, Volume 3, Reproductive Systems, Science Publishers, USA. 3. **Raghavan V.**2000. Developmental Biology of Flowering Plants, Springer-Verlag, New York. 4. **Bhojwani S. S. and Bhatnagar S. P.**1992. The Embryology of Angiosperms, Vikas Publishing House Pvt. Ltd., New Delhi. 5. **Johri B.M.**1984. Comparative Embryology of Angiosperms, Ind. Nat. Sci. Acad., New Delhi. 6. **Maheshwari P.**1985. An Introduction to Embryology of Angiosperms, Tata McGraw Hill, New Delhi. 7. **Fahn. A.**1990. Plant Anatomy, 4th Edition, Pergamon press, New York, Oxford. 8. **Esau K.**1985. Plant anatomy, 2nd Edition, Wiley Eastern Limited, New Delhi. 9. **Metcalf C. R. and Chalk L.**1950. Anatomy of Dicots Vol. I & II, London Press, Oxford. 10. **Romberger J. A., Hejnowicz Z. and Hill J. F.**1993. Plant Structure: Function and Development, Springer-Verlag. 11. **Nair P.K.K.** Essentials of Palynology, Asha Publishing House, New York. 12. **Shivanna, K. R. and Sawhney V. K.**1997. Pollen Biotechnology for Crop Production and Improvement, Cambridge University press. U.K. 13. **Lyndon R. F.**1990. Plant Development, the Cellular Basis. Cambridge University Press, UK. 14. **Hesse M. and Ehrendorfer F.**1990. Morphology, Development and Systematic Relevance of Pollen and Spores, Springer-Verlag, New York.	

	15. **Kashinath Bhattacharya, M. R. Majumdar and S. G. Bhattacharya.** 2006. A text Book of Palynology, New Central Book Agency (P) Ltd., Kolkata, India.	
Learning Outcomes	1. Being able to apply the knowledge of anatomy, structure and functions to all flowering plants. 2. Being able to apply the embryological processes and applied aspects of embryology in various situations. 3. Being able to apply the knowledge of pollen biology and biotechnology and methods and techniques learnt to various situations and applications.	

Programme: M. Sc. (Botany)
Course Code: BOC-222
Title of the Course: Lab in Internal Morphology and Developmental Biology of Angiosperms
Number of Credits: 1 (24 hours)
Effective from AY: 2020-21

Prerequisites for the course:	Should have studied B. Sc. Botany (6 or 3 Units). It is assumed that students have a basic knowledge of anatomy and developmental biology of higher plants.	
Objective:	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 flowers and honey samples.	
Content:	1. Comparative anatomy of monocotyledon and dicotyledon root, stem and leaf. 2. Anatomical basis of identification C_3& C_4 sub types in grasses. 3. Phytoliths of grasses and their potential use in identification. 4. Anatomy of lenticels and periderm in plants. 5. Anatomy of monocotyledonous and dicotyledonous seeds. 6. Study of different types of stomata and trichomes. 7. Maceration of wood to study xylem components. 8. Study of microsporangium and microsporogenesis. 9. Study of megasporangium and embryo sac development. 10. Study of types of endosperm and its modifications. 11. Study of development of embryo in dicot and monocot. 12. Study of different ornamentation patterns in pollen	**2 hours** **2 hours** **2 hours** **2 hours** **2 hours** **2 hours** **4 hours** **2 hours** **2 hours** **2 hours** **2 hours** **4 hours**

	grains by acetolysis. 13. Analysis of honey samples to identify uni-floral or multi-floral honey.	**4 hours**
Pedagogy:	Hands on Practical.	
References/Readings	1. **Shivanna, K. R. and Rangaswamy N. S.**1992. Pollen Biology - A Laboratory Manual, Narosa Publishing House, New Delhi. 2. **Batygina T. B.**2009. Embryology of Flowering Plants Terminology and Concepts, Volume 3, Reproductive Systems, Science Publishers, USA. 3. **Raghavan V.**2000. Developmental Biology of Flowering Plants, Springer-Verlag, New York. 4. **Bhojwani S. S. and Bhatnagar S. P.**1992. The Embryology of Angiosperms, Vikas Publishing House Pvt. Ltd., New Delhi. 5. **Johri B.M.**1984. Comparative Embryology of Angiosperms, Ind. Nat. Sci. Acad., New Delhi. 6. **Maheshwari P.**1985. An Introduction to Embryology of Angiosperms, Tata McGraw Hill, New Delhi. 7. **Fahn. A.**1990. Plant Anatomy, 4th Edition, Pergamon press, New York, Oxford. 8. **Esau K.**1985. Plant anatomy, 2nd Edition, Wiley Eastern Limited, New Delhi. 9. **Metcalf C. R. and Chalk L.**1950. Anatomy of Dicots Vol. I & II, London Press, Oxford. 10. **Romberger J. A., Hejnowicz Z. and Hill J. F.**1993. Plant Structure: Function and Development, Springer-Verlag. 11. **Nair P.K.K.** Essentials of Palynology, Asha Publishing House, New York. 12. **Shivanna, K. R. and Sawhney V. K.**1997. Pollen Biotechnology for Crop Production and Improvement, Cambridge University press. U.K. 13. **Lyndon R. F.**1990. Plant Development, the Cellular Basis. Cambridge University Press, UK. 14. **Hesse M. and Ehrendorfer F.**1990. Morphology, Development and Systematic Relevance of Pollen and Spores, Springer-Verlag, New York. 15. **Kashinath Bhattacharya, M. R. Majumdar and S. G. Bhattacharya.** 2006. A text Book of Palynology, New Central Book Agency (P) Ltd., Kolkata, India.	
Learning Outcomes	1. Being able to apply the knowledge of anatomy, structure and functions to all flowering plants.	

	2. Being able to apply the embryological techniques and methods to various plant species and situations. 3. Being able to apply the knowledge of pollen biology and methods and techniques to various plant species. 4. Environmental biomonitoring of pollen allergens.	

Programme: M.Sc. Botany
Course Code: BOC-225
Title of the Course: Plant Physiology
No. of Credits: 3
Effective from AY: 2020-21

Prerequisite for course	Knowledge of the subject at UG level.	
Objective	This course teaches processes of 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. The Course also teaches Plant growth and development due to light and phytohormones with emphasizes on cellular and molecular mechanism of signal transduction and physiological response.	
Content	The physico-chemical organisation of the plant cell and cell organelles; structure and composition of plasma membrane fluid mosaic lipo-protein model, membrane, Water relation of plants, unique physico chemical properties of water; bulk movement of water and substances across the membrane, aquaporins, stomatal regulation of transpiration, anti transpirants.	**4hours**
	Inorganic nutrition, macro and micro nutrients, deficiency symptoms, hydroponic studies; mineral absorption and translocation and assimilation; Nernst equation and Donnan's equilibrium.	**2 hours**
	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.	**3 hours**
	Photosynthesis: Importance of photosynthesis, Photosynthesis and environment. Light reaction: Radiant energy, photosynthetic apparatus, pigments and their biosynthesis; light harvesting complex; characteristics of two photosystems, photosynthetic electron transport, water oxidation and its molecular mechanism, photophosphorylation, pseudocyclic electron transport (Mehler reaction).	**5 hours**

	Dark reaction: Carbon dioxide fixation in C3, C4 and CAM plants regulation of PCR cycle; photorespiration and its regulation, environmental factors affecting photosynthesis.	**3 hours**
	Respiration: Aerobic and anaerobic respiration; cyanide independent respiration; cytochrome system; carbohydrate and lipid metabolism; high energy compounds and factors affecting respiration. ROS generation, effect and metabolism	**6 hours**
	Enzymes: Structure and classification; mechanism of action; Michaelis-Menten equation; Lineweaver-Burk plot; enzyme regulation; allosteric enzymes, isozymes, co-enzymes and vitamins.	**2 hours**
	Growth and development: Phytochromes and light control, regulatory mechanism; role of phytochrome in phototropism; physiology of flowering and fruiting.	**2 hours**
	Phytohormones: Auxin; cytokinin; Gibberellins; ethylene; ABA. polyamines; brassinosteroids, jasmonate, their synthesis, distribution; and physiological effects. Molecular mechanism of action.	**5 hours**
	Stress Physiology: Abiotic stresses (drought, salt and metal), morphological and cellular adaptation; molecular mechanism of stress tolerance and protection.	**4 hours**
	Seed dormancy and germination, senescence, circadian rhythms in plants (exogenous factors and molecular mechanism).	
Pedagogy	Lecture through PPT/E-learning/Assignments/Seminars/LSM Moodle	
Reading/reference	1. **Nair, L. N.** (2007). Topics in Mycology and Pathology, New Central Book agency, Kolkata. 2. **Taiz L. and Zeiger E. Plant Physiology. Panima, New Delhi** Henry R.J. Plant Molecular Biology. Chapman and Hall, Panima, New Delhi. 3. **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. 4. **Hopkins, W.G. Introduction to Plant Physiology, Wiley, New York**. Luttuge U. Physiological Ecology of Tropical plants. Springer. 5. **Mengel K**. Principles of Plant Nutrition, Panima. 6. **Salisbury F.B.** Plant Physiology. 7. **Thomson Tesar M.B.** Physiological basis of crop growth and development, Panima. 8. **Wills R.** Post harvest: An introduction to the physiology and handling of fruit. Nobel P.S. Physiological and environmental Plant Physiology. Allied Press.	

9. **Buchanan B.B., Gruissen W. and Jones R.L.** Biochemistry and Molecular Biology of Plants, ASPP.
10. **Finkelstein A.** Water movement through lipid bilayers, pores and plasma membranes: Theory and reality. Wiley, New York.
11. **Friedman M.H.** Principle and models of biological transport. Springer-Verlag. Stein W.D. Transport and diffusion across cell membrane. Academic press.
12. **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.
13. **Lauchli A. and Bieleski** Inorganic plant Nutrition. Springer Brady N.C. The nature and properties of soils. Macmillan.
14. **Epstein E.** Mineral nutrition of plants: Principles and perspectives. Wiley, New York.
15. **Marschner H.** Mineral nutrition of higher plants.
16. **Mengel K. and Kirkby E.A.** principles of plant nutrition. Worblaufen-Bern, Switzerland.
17. **Luttuge U and Higinbotham N.** Transport in plants. Springer-Verlag, Germany Small J. pH and Plants, an introduction to beginners. Nostrand, New York.
18. **Hall D.O and Rao K.K. Photosynthesis Edwards-Arnold**,
19. Coombs J., Hall D.O., Long, S.P. and Scurlock J.M.O. Techniques in bioproductivity and Photosynthesis. Pergamon, Oxford.
20. **Blankenship R.E.**Molecular Mechanism of photosynthesis Blackwell Science, Oxford.
21. **Edwards G.E. and Walker D.** C3-C4 mechanisms and cellular and environmental regulation of photosy nthesis. Univ. California Press.
22. **Pollock C.J., Farrar J.F. and Gordon, A.J.** Carbon partitioning within and between organisms. BIOS Scientific, Oxford.
23. **Davies D.** The Biochemistry of Plants Academic Press.
24. **Dennis D.T., Turnip D.H., Lefebvre, D.D. and Layzell D.B.** Plant Metabolism. Longman, Singapore.
25. **Douce R.** Mitochondria in higher plants: Structure, function and Biogenesis. Academic Press.
26. **Douce R and Day D.A.** Higher plant cell respiration. Springer, Berlin.
27. **Nicholls D.G. and Ferguson S. J.** Bioenergetics. Academic Press.
28. **Dixon R.O.D. and Wheeler C.T.** Nitrogen fixation in plants. Chapman and Hall, New York.
29. **Wray J. L. and Kinghorn J.R.** Molecular and genetic aspects of nitrate assimilation. Oxford Science, Oxford.

	30. **Mann.** Secondary Plant Metabolites. 31. **Karban R. and Baldwin I.T.** Induced response to herbivory. Uni. Chicago press. Galston A. Life processes of Plants. Sci. Am. Library, New York. 32. **Kendrick R.E. and Frankland B.** Phytochrome and Plant Growth. Edward-Arnold, London. 33. **Smith H.** Phytochrome and photomorphogenesis: An introduction to the photocontrol of plant development. McGraw Hill London. 34. **Senger H.** Blue light effects in biological systems. Springer, Berlin. 35. **Davies P.J.** Plant Hormone and their role in plant growth development. Kluwer, Dordrecht, Netherland. 36. **Bopp M.** Plant Growth substances. Springer, Berlin. 37. **Moore T.D.** Plant Growth regulators. Kluwer, Dordrecht. The Netherland. Cherry J.H. Environmental Stress in plants. Springer, Berlin. 38. **Mussel H. and Staples R.C.** Stress physiology in crop plants. Wiley New York. 39. **Levitt J.** Response of plants to environmental stresses. Academic press, New York.
Learning outcome	Students will be able to demonstrate a depth of knowledge of physiological processes together with a better understanding of interaction and regulation of growth, metabolism and development and influence of environment on plant and further will be able to communicate scientific ideas in both written and oral forms to diverse audiences.

Programme: M.Sc. Botany
Course Code: BOC-226
Title of the Course: Lab in Plant Physiology
No. of Credits:1
Effective from AY: 2020-21

Prerequisite for course	Knowledge of the subject at UG level to be able to prepare various types of solutions, set pH, and handle basic laboratory tools and techniques. Preferably taken paper BOO 121 and 122	
Objective	This course is designed primarily to relate the learning of concepts in classroom to demonstrate experimental foundation of underline concepts/principles mainly on aspects of biological molecules, photosynthesis, respiration, transport, growth, growth substances and the stress physiological aspects of crop yield.	
Content	1. Verification of law of diffusion and osmosis	**2hours**
	2. Determination of water potential and osmotic potential	**2 hours**

	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 hours**
	4. Quantitative estimation of protein.	**2 hours**
	5. Determination of ascorbic acid content of tissue.	**2 hours**
	6. Separation of protein by PAGE.	**2 hours**
	7. Pigments extraction, separation, identification and quantification.	**2 hours**
	8. Photo-oxidation of plant pigments.	**2 hours**
	9. Determination of oxidative damage in tissue using TBARS method	**2 hours**
	10. Enzyme activity with respect to temperature or pH or substrate concentration.	**4hours**
	11. Isolation of intact organelles: chloroplasts and mitochondria.	**2 hours**
	12. Assay of photosynthetic electron transport activity from isolated chloroplast using oxygraph.	**2 hours**
	13. Assay of respiratory electron transport activity from isolated mitochondria using oxygraph.	**2 hours**
	14. Non-invasive measurements of photosynthesis (chlorophyll fluorometer).	**2 hours**
	15. Assay of nitrate/nitrite reductase activity in leaves/algae.	**2 hours**
	16. Estimation of Proline under stress and normal conditions.	**2 hours**
Pedogogy	Wet laboratory exercises	
Reading/reference	1. **D.T. Plummer,** An introduction to practical Biochemistry. Tata McGraw Hill publishing company Limited. New Delhi. 2. **J.B. Harborne,** Phytochemical Methods. Chapmann and Hall. London.	
Learning outcome	The understanding of the rationale behind the practical procedures and ability to interpret the observations will enhance the student's ability to modify/design their own procedures if necessary as they advance to higher levels. They will develop ability to apply the knowledge of plants symptoms/observation to their underline physiological causes.	

Programme: M. Sc. (Botany)
Course Code: BOC-321
Title of the Course: Plant Molecular Biology
Number of Credits: 3
Effective from AY: 2020-21

Prerequisites for the course:	Should have studied B. Sc. Botany. It is assumed that students have a basic knowledge of biochemistry and molecular biology.	
Objective:	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.	
Content:	**1. Introduction to Molecular Genetics and Genomics:** History of DNA molecule & discoveries 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. Organization of DNA. How Genes function at Molecular level - Replication, Transcription & Translation.	**5 hours**
	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.	**6 hours**
	3. Molecular Biology of Recombination: Molecular mechanisms of Recombination, Gene conversion, Mismatch repair, the Holliday model of recombination, Single strand break & repair model.	**3 hours**
	4. Transcription: Enzymes in transcription; Basic features of transcription, Initiation elongation and termination, promotors and enhancers; prokaryotic and eukaryotic transcription.	**5 hours**
	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	**6 hours**

	Salmonella and*Trypanosoma*. **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). **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.	**5 hours** **6 hours**
Pedagogy:	Lectures/ Tutorials/Assignments/Seminars/Self-Study	
References/Readings	1. **Burton E. Tropp.** 2012. Molecular Biology. Fourth Edition. Jones and Bartlett India Pvt. Ltd, New Delhi. 2. **David Freifelder.** 1990. Molecular Biology. Second Edition. Narosa Publishing House, New Delhi. 3. **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. 4. **Primrose, S. B. and R. M. Twyman.** 2009. Principles of Gene Manipulation and Genomics. Seventh Edition. Blackwell Publishing, U.S.A. 5. **Brown T. A.** 2007. Genomes. Third Edition. Garland Science Publishing, New York. U.S.A. 6. **Benjamin Lewin.** 2008. GENES IX. Jones and Bartlett Publishers, London, UK. 7. **Mary A. Schuler and Raymond E. Zielinski.** 2005. Methods in Plant Molecular Biology. Academic Press, USA. 8. **R. J. Henry.** 2005. Practical Applications of Plant Molecular Biology. Chapman & Hall, London, UK. 9. **Shaw, C. H.** 1988. Plant Molecular Biology, Practical Approach. IRL Press, Oxford, Washington DC. 10. **Grierson D and S. Covey.** 1984. Plant Molecular Biology. Panima Educational Agency, New Delhi. 11. **Gloria Coruzzi.** 1994. Plant Molecular Biology - Genetic Analysis of Plant Development and Metabolism. Springer-Verlag, New York, London. 12. **Tewari, K. K. and G. S. Singhal.** 1997. Plant Molecular Biology and Biotechnology. Narosa Publishing House, New Delhi.	
Learning Outcomes	1. Being able to apply the knowledge of various molecular	

	biological processes of DNA replication, transcription and translation to various other organisms. 2. Molecular biology of recombination, synthesis and processing of various RNA molecules could be employed in various situations and applications. 3. Being able to apply the regulation of gene expression to various other organisms.	

Programme: M.Sc. Botany
Course Code: BOC-323
Title of the Course: Plant Genetic Engineering
No. of Credits: Three (3)
Effective from AY: 2020-21

Prerequisite for course	Knowledge of the subject at UG level.	
Objective	This course is designed to understand basic principles, tools, techniques and recent advances in plant genetic engineering. Students will be exposed to restriction 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 sequencing, PCR, RT-PCR, RNAi *etc*.to study gene amplification and their expression. This paper also discusses other application of genetic engineering such as genetic marking and Molecular taxonomy.	
Content	Introductory lecture on application of genetic engineering in the field of Plant science with regard to Agriculture, environment and medical field and study of plant taxonomy.	**2hours**
	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 and their growth cycle and regulation; various cloning strategies, Genome library and cDNA library, selection strategies for desired transformants, Genetic system provided by *E. Coli* and its host.	**8 hours**
	Agrobacterium-mediated gene transfer: Biology and molecular basis of Agrobacterium mediated plant transformation and its application. Other direct gene transfer methods. Conventional Plant Breeding vs Genetic Engineering.	**4 hours**
	Site directed mutagenesis: DNA sequencing, various strategies for carrying out site directed mutagenesis.	**3 hours**
	Structure, function and regulation of genome: General organization and replication, transcription and translation of , mitochondrial and	**6 hours**

	chloroplast genome; Genetic interactions in nucleus, chloroplast and mitochondria (retrograde signaling/plastid factors); Genetic codes in organelles;	
	Gene silencing, editing, sequencing, amplification expression in plants: Post transcriptional and transcriptional gene silencing (RNAi, Antisense), Gene editing and its application (CRISPER-CAS9), mutants of gene silencing, RNA virus in plants, virus induced gene silencing, Dideoxy and other methods of sequencing, PCR, RT-PCR and microarrays.	**6 hours**
	Application of plant genetic engineering: Genetic engineering of plants for various desired characters (herbicide resistance, insect resistance, virus and abiotic stress resistance; to improvement of crop yield and quality; rice genome project, other sequenced genomes, (With relation to matter discussed above)	**5 hours**
	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. Field testing of transgenic plants; Bio-safety issues in Indian contest; Indian rules, regulation and procedures for handling transgenic plants.	**2 hours**
Pedagogy	Lectures/E-learning/Assignments/Seminar/Moodle/Group discussion	
Reading/ reference	1. **David Freifelder.** 1987. Molecular Biology. Second Edition. Narosa Publishing House, New Delhi. 2. **R. W. Old and S. B. Primerose.** Principles of Gene Manipulation. An Introduction to Genetic Engineering. 3. **Benjamin Lewin**. 1999. GENES VII. Oxford University Press. 4. **O'Brien, L. and R. J. Henry.** Transgenic cereals, American Association of Cereal Chemists, St. Paul, Minnesota, USA. 5. **Shaw, C. H.** 1988. Plant Molecular Biology-Practical Approach. IRL Press, Oxford, Washington DC. 6. **Grierson D and S. Covey.** 1984. Plant Molecular Biology. Panima Educational Agency, New Delhi. 7. **Gloria Coruzzi** 1994. Plant Molecular Biology-Genetic Analysis of Plant Development and Metabolism. Springer-Verlag, New York, London. 8. **Tewari, K. K. and G. S. Singhal.**1997. Plant Molecular Biology and Biotechnology. Narosa Publishing House, New Delhi. 9. Books referred for BOC-321Plant Molecular Biology should also be read.	
Learning outcome	After completing this course student should be able to understand basic principles of plant genetic engineering in order to develop and validate transgenic plants.	

Programme: M. Sc. (Botany)
Course Code: BOC-324
Title of the Course: Lab in Plant Molecular Biology and Genetic Engineering
Number of Credits: 2 (48 hours)
Effective from AY: 2020-21

Prerequisites for the course:	Should have studied B. Sc. Botany. It is assumed that students have a basic knowledge of biochemistry, molecular biology and instrumental techniques at UG level.	
Objective:	To learn and understand various methods, techniques and hands on experiments with techniques concerning study of plant molecular biology and genetic engineering. This course is designed to introduce students to both the principles and the applications of molecular recombinant DNA technology to plants and microbial organisms. It describes the use of genetically engineered products to solve agriculture and environmental problems for human welfare.	
Content:	1. Preparation of media and other requirements, sterilized glassware etc.	2 hours
	2. Isolation and purification of genomic DNA from plant materials.	2 hours
	3. Isolation and purification of RNA from plants.	2 hours
	4. Culture of plasmid and maintenance of culture.	2 hours
	5. Isolation of plasmid DNA.	2 hours
	6. Quantitative estimation of genomic DNA and RNA using spectrophotometer.	2 hours
	7. Agarose gel electrophoresis of genomic DNA and RNA and detection using gel documentation system.	2 hours
	8. Digestions of DNA by restriction enzymes and size fractionation of fragments.	2 hours
	9. Ligation of digested fragments.	2 hours
	10. Primer designing.	2 hours
	11. cDNA formation using reverse transcriptase.	4 hours
	12. RT-PCR quantitation of selected gene(s) using SYBRG.	4 hours
	13. Use of software for quantitation of gene and compare the expression level.	2 hours
	14. Southern Blotting/Northern Blotting/Western Blotting (any one)	2 hours
	15. Creating a transformant using commercial construct.	4 hours
	16. 16 or 18s rRNA analysis.	4 hours
	17. Leaf disc transformation using Agrobacterium, establishment of transgenic plants and GUS staining of GFP viewing.	4 hours
	18. Amplification of genomic DNA using ISSR/ RAPD	4 hours

	random primers in PCR and agarose gel electrophoresis and detect the banding patterns under gel documentation system and analysis of bands to understand genetic variation in plants.	
	Any 15 experiments will be conducted depending on availability of material/equipments etc.	
Pedagogy:	Hands on practicals.	
References/ Readings:	1. Burton E. Tropp. 2012. Molecular Biology. Fourth Edition. Jones and Bartlett India Pvt. Ltd, New Delhi. 2. David Freifelder. 1990. Molecular Biology. Second Edition. Narosa Publishing House, New Delhi. 3. James D. Watson, Tania A. Baker, Stephen P. Bell, Alexander Gann, Michael Levine and Richard Losick. 2008. Molecular Biology of Gene. Sixth M.Sc Syllabus - 2018 Core 29 Edition. Cold Spring Harbor Laboratory Press, Cold Spring Harbor, New York.U.S.A. 4. Primrose, S. B. and R. M. Twyman. 2009. Principles of Gene Manipulation and Genomics. Seventh Edition. Blackwell Publishing, U.S.A. 5. Brown T. A. 2007. Genomes. Third Edition. Garland Science Publishing, New York. U.S.A. 6. Benjamin Lewin. 2008. GENES IX. Jones and Bartlett Publishers, London, UK. 7. Mary A. Schuler and Raymond E. Zielinski. 2005. Methods in Plant Molecular Biology. Academic Press, USA. 8. R. J. Henry. 2005. Practical Applications of Plant Molecular Biology. Chapman & Hall, London, UK. 9. Shaw, C. H. 1988. Plant Molecular Biology, Practical Approach. IRL Press, Oxford, Washington DC. 10. Grierson D and S. Covey. 1984. Plant Molecular Biology. Panima Educational Agency, New Delhi. 11. Gloria Coruzzi. 1994. Plant Molecular Biology - Genetic Analysis of Plant Development and Metabolism. Springer-Verlag, New York, London. 12. Tewari, K. K. and G. S. Singhal. 1997. Plant Molecular Biology and Biotechnology. Narosa Publishing House, New Delhi. 13. C. Neal Stewart Jr. Plant Biotech and genetics: Principle, techniques and applications. Wikley jones and Sons, Canada 14. J.H. Dodds. Plant Genetic Engineering. Cambridge University Press. 15. Isil Aksan Kurnaz. Techniques in Genetic Engineering. CRC Press	
Learning	After completing this course student should be able to	

Outcomes:	recognize the foundations of modern biotechnology and explain the principles that form the basis for recombinant DNA technology and be able to carry out R & D work or work in quality control laboratory on molecular biology and recombinant DNA technologies such as vector construction, cloning and gene expression etc.	

Programme: M. Sc. (Botany)
Course Code: BOC - 421
Title of the Course: Cytogenetics and Plant Breeding.
Number of Credits: 3
Effective from AY: 2020-21

Prerequisites for the course:	Should have studied B. Sc. Botany. It is assumed that students have a basic knowledge of Genetics and Plant Breeding.	
Objective:	The paper provides the students with detailed concepts of cytogenetic and Plant breeding.	
Content:	**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 and Viral genomes. **2. Morphology of eukaryotic chromosomes:** Chromosome number, size and general morphology; Karyotype; Chromosomes banding patterns; Specialized chromosomes; B chromosomes; Chromosome movement; Prokaryotic nucleoids; Fluorochromes. **3. Molecular organization of Eukaryotic chromosomes:** Chemical composition, chromosome structure; Organization of chromatin fibres; Molecular structure of Centromere and telomere. **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. **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; AC-DC and Spm in corn; Retroelement (viral and non viral); Mechanism of	**5 hours** **4 hours** **3 hours** **3 hours** **3 hours** **3 hours**

	transposition, uses of transposons. **6. Molecular mechanisms to mutation and DNA repair**: Types of mutations; Molecular basis of mutations; mutagens, mechanism of DNA repair. **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. **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. **9. Distance hybridization and *in-vitro* techniques in plant breeding:** Distant hybrids and barriers in the production of distant hybrids, Application in crop improvement; embryo, Meristem, anther and pollen culture, achievements. **10. Genetics and crossing techniques of economically important crop plants:** Wheat, Rice, Maize and Cotton.	**4 hours** **5 hours** **3 hours** **3 hours**
Pedagogy:	Lectures/Assignments/Tutorials/Self study.	
References/Readings	**1. Strickberger, M. W.** (1985). Genetics. 3rd Edition. MacMillan Pub. Co., Philadelphia. **2. Gupta, P. K.** (2000). Cytology, Genetics and Evolution. 6th Edition. Rastogi Publications, Meerut. **3. Lewin, B.** (2008) Genes IX. Oxford Univ. Press, New York. **4. Darlington, C. D.** (1965) Cytology, Churchill. London. **5. De Robertis, E.D.P. and E.M.F. De Robertis** (1987) Cell and Molecular Biology. 8th Edition. B. I. Waverly, New Delhi. **6. Watson, J. D. et al.,** (2009) Molecular Biology of the Gene. 6th Edition. Benjamin Cummings, New York. **7. Broda, P. W.** (1979) Plasmids. Freeman. Oxford. **8. Swaminathan, M. S., P. K. Gupta and U. Sinha** (1983) Cytogenetics of crop plants. MacMillan India Pvt. Ltd., New Delhi. **9. Swanson, C. P. and P. L. Webster** (1989) The Cell. 7th Edition Prentice-Hall of India Pvt. Ltd. New Delhi. **10. Sinha, U and S. Sinha** (1989) Cytogenetics, Plant Breeding and Evolution. Vikas Publishing House Pvt.	

	Ltd. New Delhi. 11. **Allard, R. W.** (1999) Priniciples of Plant Breeding. 2nd Edition. John Wiley, New York. 12. **Singh, B. D.** (2003) Plant Breeding – Principles and Methods. Kalyani Publishers, New Delhi. 13. **Sharma, J. R.** (1994) Principles and Practice of Plant Breeding. Tata Mc Graw-Hill Publishing Co. Ltd., New Delhi. 14. **Poehlman, J. M. and D. Borthakur** (1969) Breeding Asian Field Crops. Oxford and IBH Publishing Co. New Delhi.	
Learning Outcomes	1. The candidates can work in Research institutes like ICAR. 2. The candidates can start their own entrepreneurship in Tissue culture and breeding. 3. The candidates can work in Tissue culture laboratories.	

Programme: M. Sc. (Botany)
Course Code: BOC – 422
Title of the Course: Lab in Cytogenetics and Plant Breeding.
Number of Credits: 1 (24 hours)
Effective from AY: 2020-21

Prerequisites for the course:	Should have studied B. Sc. Botany with basic knowledge of Genetics and Plant Breeding.	
Objective:	To develop hands on training skills in Cytogenetics and Plant Breeding.	
Content:	1. Mitotic studies in suitable material: Squashing of the root tip and selection of metaphase plate. 2. Mitotic studies in suitable material*:* Camera Lucida drawing, Karyotype analysis, ideogram and derivation of karyotypic formula. 3. To study chromosomal aberrations in *Rheo sp.* 4. Meiosis in *Allium cepa.* 5. Induction of polyploidy in onion root tips**.** 6. Observation of B chromosomes in suitable material – *Zea mays.* 7. Centre of origin of some economically important crop plants. 8. Floral biology of *Oryza sativa*. 9. Floral biology of *Zea mays.* 10. Effect of chemical mutagen (DES/HZ/EMS) on germination, growth and yield characteristics in *Brassica juncea /Impatiens balsamina.*	**2 hours** **6 hours** **2 hours** **2 hours** **2 hours** **2 hours** **2 hours** **2 hours** **2 hours** **4 hours**

	11. Crossing techniques in *Oryza sativa*. 12. Crossing techniques in *Zea mays*. 13. *In vitro* embryo culture of pea (*Pisum sativum*)	**2 hours** **2 hours** **4 hours**
Pedagogy:	Laboratory practicals.	
References/Readings	1. **Strickberger, M. W.** (1985). Genetics. 3rd Edition. MacMillan Pub. Co., Philadelphia. 2. **Gupta, P. K.** (2000). Cytology, Genetics and Evolution. 6th Edition. Rastogi Publications, Meerut. 3. **Lewin, B.** (2008) Genes IX. Oxford Univ. Press, New York. 4. **Darlington, C. D.** (1965) Cytology, Churchill. London. 5. **De Robertis, E.D.P. and E.M.F. De Robertis** (1987) Cell and Molecular Biology. 8th Edition. B. I. Waverly, New Delhi. 6. **Watson, J. D. et al.,** (2009) Molecular Biology of the Gene. 6th Edition. Benjamin Cummings, New York. 7. **Broda, P. W.** (1979) Plasmids. Freeman. Oxford. 8. **Swaminathan, M. S., P. K. Gupta and U. Sinha** (1983) Cytogenetics of crop plants. MacMillan India Pvt. Ltd., New Delhi. 9. **Swanson, C. P. and P. L. Webster** (1989) The Cell. 7th Edition Prentice-Hall of India Pvt. Ltd. New Delhi. 10. **Sinha, U and S. Sinha** (1989) Cytogenetics, Plant Breeding and Evolution. Vikas Publishing House Pvt. Ltd. New Delhi. 11. **Allard, R. W.** (1999) Priniciples of Plant Breeding. 2nd Edition. John Wiley, New York. 12. **Singh, B. D.** (2003) Plant Breeding – Principles and Methods. Kalyani Publishers, New Delhi. 13. **Sharma, J. R.** (1994) Principles and Practice of Plant Breeding. Tata Mc Graw-Hill Publishing Co. Ltd., New Delhi. 14. **Poehlman, J. M. and D. Borthakur** (1969) Breeding Asian Field Crops. Oxford and IBH Publishing Co. New Delhi.	
Learning Outcomes	Upon completion of this course, the students will be able to take up job assignments in agri-based industries or work as research assistants on research projects.	

Programme: M.Sc. Botany
Course Code: BOO-121
Title of the Course: Techniques and instrumentation in Botany.
No. of Credits: 3
Effective from AY: 2020-21

Prerequisite for course	Knowledge of chemistry, biochemistry, instrumental techniques at UG level	
Objective	This paper teaches basic of various types of techniques and instrumentation such as spectrophotometry, chromatotgraphy, electrophoresis, scintillation and current molecular techniques 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 of the technique in the field of Botany.	
Content:	Laboratory practices and safety in laboratory: General safetymeasure, Chemical hazards, Physical hazards, Biologicalhazards, spillage and waste disposal, disposal of radioactivewaste, first aid, MSDS.	**2 hours**
	pH and buffer solutions: SI units; Molarity and moles; Acids andbase; Hydrogen ion concentration and pH, Dissociation of acidsand bases; Buffer solutions.	**3 hours**
	Centrifugation Techniques: Basic principles of sedimentation; RCF and g forces, Density gradient centrifugation; design and care of rotors, safety aspects in the use of centrifuges.	**2 hours**
	Spectroscopic Techniques: General principles; Radiation energyand atomic structure; Basic law of light absorption; Types ofspectra and their biological usefulness. Principle, application andinstrumentation of UV-VIS spectrophotometry; IR (infra-red)spectrophotometry; Spectrofluorometry, Atomic/flamespectrophotometry; Mass spectrometry.	**9 hours**
	Chromatography Techniques: General Principles and techniquesand application and material of column chromatography forAdsorption, partition, molecular sieving, ion exchange andaffinity chromatography.Factors influencing the resolution.Column development- isocratic, gradient solvent and thermaldevelopment. Chromatogram reading and qualitative andquantitative determination of peaks in a chromatogram	**8 hours**
	Electrophoresis Techniques: General principles, application of Isoelectric focusing, SDS–PAGE (sodium dodecyl sulphate), 2D electrophoresis, Blotting techniques; Detection, recovery and estimation.	**6 hours**
	Radiobiology: The nature of radioactivity; Atomic structure, stability and radiation; Isotopes; Types of radioactive decay; Detection and measurement of radioactivity; Applications of radioisotopes in biological sciences; Safety aspects of use of	**2 hours**

	radioisotopes.	
	Molecular techniques: Protein Crystallography, Microarray analysis, yeast hybrid assay, Immunoprecipitation assay, EMSA, DNAse footprinting, Surface Plasmon resonance, Proximity labeling.	6 hours
Pedagogy	Lecture through PPT/E-learning/Assignments/Seminars/LSMMoodle	
Reading/ Reference	1. **Bauman R.P.** Absorption Spectroscopy. John Wiley, New York 2. **Dixon R.N.** Spectroscopy and Structure. Mathuen, London 3. **Sacks R.D.** Emission Spectroscopy. John Wiley, New York 4. **Pesez M and Bartos J.** Colorimetric and Fluorometric Analysis of Organic Compounds and drugs, Dekker, New York. 5. **Becker R.S.** Theory and interpretation of fluorescence and phosphorescence, Wiley interscience, New York. 6. **Guilbault G.G.** Practical Fluorescence: Theory, methods and Techniques. Dekker, New York. 7. **Dean J. and Rains T.** Flame emission and atomic absorption. Dekker, New York. 8. **Brech F.** Analysis in instrumentation. Vol. 6. Plenum, New York. 9. **Bell R. J.** Introductory Fourier Transform spectroscopy. Academic Press, New York. 10. **Colthup N.B., Daly L.H. and Wiberley S.E.** Introduction to Infra-red and Raman Spectroscopy 2nd Ed. Academic Press. New York. 11. **Kolthoff I.M. and Elving P. J.** Treatise on analystical Chemistry, Wiley Interscience, New York. 12. **Williams D.A.R. and Mowthorpe D. J.** Nuclear Maganatic Resonance Spectroscopy. John Wiley, New York. 13. **Watson I.J.** Introduction to Mass spectroscopy, Raven, New York. 14. **Giddings J.C.** Principles and Theory, Dynamics of Chromatogtraphy Part I Dekker, New York. 15. **Grob R.L.** Modern Practices of Gas Chromatography. 2nd Ed. John Wiley, New York. 16. **Simpson C.F.** Techniques in liquid chromatography, Wiley-Heyden, New York. Horvath C. HPLC Vol.I Academic Orlando. F.L. Fritz J.S., GjerdeD.T. and Pohlandt C. Ion chromatography, A. Huthig, Heidelberg 17. **Yau W. W., Kirkland J.J. and Bly D.D.** Modern size exclusion chromatography, Wiley Interscience, New York. 18. **Bailey P.L.** Analysis and ion selective electrodes 2nd Ed. Heyden, London. 19. **Bates R.G.** Determination of pH: Theory and Practices, 2nd Ed. John Wiley, New York. 20. **Willard H.F., Merritt L.L., Dean, J.A. and Settle F.A.**	

	Instrumental Method of analysis. CBS Publishers and distribution, New Delhi 21. **Sharma, B.K.** Principal of analytical chemistry, Meerut Publication, Meerut. 22. **Hames B.D. and Rickwood D.** Gel electrophoresis of Proteins: A practical approach 2nd ed. IRL Press, Oxford. **23. Karp, G.** (2009). Cell and molecular biology: Concepts and experiments, 7th edition. John Wiley & Sons, USA. **24. Reece, R. J.** (2004). Analysis of genes and genomes.John Wiley & Sons Ltd. **25. Saraswathy, N. and Ramalingam, P.** (2011) Concepts and Techniques in Genomics and Proteomics. Biohealthcare Publishing (Oxford) Limited, New York. **26. Walker, J. M. and Rapley, R.** (2008). Molecular Biomethods Handbook, Hertfordshire, UK.	
Learning Outcome:	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.*	

Programme: M.Sc. Botany
Course Code: BOO-122
Title of the Course: Lab in Techniques and Instrumentation in Botany
No. of Credits: 1
Effective from AY: 2020-21

Prerequisite for course	Knowledge of chemistry, biochemistry, instrumental techniques at UG level	
Objective	Understanding of basic principles and phenomena in the area of techniques and instrumentation required for biological studies. The course will provide opportunity to learn theoretical and practical preparation and enabling students to operate and maintain instrumentation, develop methods and carry out given scientific protocol and develop ability in students to scientific and analytical reasoning.	
Content	1. Preparation of molar and other solution and setting of pH.	**2 hours**
	2. Absorption spectra of various compounds to understand λ max, substance absorption.	**2 hours**
	3. Verification of Beer's law.	**2 hours**
	4. pKa value of a buffer/ amino acids using pH meter.	**2 hours**
	5. IEF* (learning of gel formation and role of various components.)	**2 hours**
	6. SDS-PAGE of membrane proteins (learning of gel formation, etc.).	**2 hours**
	7. Analysis of gel.	**2 hours**

	8. Blotting.	**4 hours**
	9. Separation of organelles based on density gradient centrifugation (Using percoll or sugar gradient).	**2 hours**
	10. TLC for separating and identifying biomolecules.	**2 hours**
	11. GC*	**2 hours**
	12. Fluorescence spectrophotmetry.	**2 hours**
	13. HPLC*.	**2 hours**
	14. Flame photometry.	**2 hours**
	15. Atomic absorption spectrophotometry*.	**2 hours**
	16. Scintillation counter*.	**2 hours**
	17. Centrifuges and rotor heads	**2 hours**
	*Demonstration only	
Reading/ reference	1. **Bates R.G.** Determination of pH: Theory and Practices, 2nd Ed. John Wiley, New York. 2. **Brech F.** Analysis in instrumentation. Vol. 6. Plenum, New York. 3. **Dixon R.N.** Spectroscopy and Structure. Mathuen, London 4. **Giddings J.C.** Principles and Theory, Dynamics of Chromatogtraphy Part I Dekker, New York. 5. **Grob R.L.** Modern Practices of Gas Chromatography. 2nd Ed. John Wiley, New York. 6. **Guilbault G.G.** Practical Fluorescence: Theory, methods and Techniques. Dekker, New York. 7. **Hames B.D. and Rickwood D.** Gel electrophoresis of Proteins: A practical approach 2nd ed. IRL Press, Oxford. 8. **Karp, G.** (2009). Cell and molecular biology: Concepts and experiments, 7th edition. John Wiley & Sons, USA. 9. **Kolthoff I.M. and Elving P. J.** Treatise on analytical Chemistry, Wiley Interscience, New York. 10. **Sharma, B.K.** Principal of analytical chemistry, Meerut Publication, Meerut. 11. **Simpson C.F.** Techniques in liquid chromatography, Wiley-Heyden, New York. Horvath C. HPLC Vol.I Academic Orlando. F.L. Fritz J.S., GjerdeD.T. and Pohlandt C. Ion chromatography, A. Huthig, Heidelberg 12. **Varcoe J. S.** Clinical Biochemistry: Techniques and instrumentation. A practical Approach. RMIT, Australia.	
Learning Outcome:	This Course will impart skill to students to be able to work in R & D and quality control laboratories in government and private organizations. Students should also be able to use modern instrumentation and classical techniques.	

Programme: M.Sc. (Botany)
Course code: BOO-123
Title of the Course: Bioinformatics
Number of Credits: 2
Effective from AY: 2020-21

Prerequisite for the Course:	Knowledge of computers, Internet, Modern biology and biochemistry.	
Objective:	Course has focus on rapidly advancing fields of basics of bioinformatics (stress on genomics and proteomics), 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	
Content:	**1. Introduction to Bioinformatics**: Nature of biological data, Overview of available Bioinformatics resources on the web, NCBI/EBI/EXPASY; Biological Databases: Nucleic acid sequence databases, GenBank/EMBL/DDBJ Protein sequence databases, PDB, SwissProt, UniProtKB, Genome databases-OMIM, structural databases, NDB, CCSD, drived databases Prosite, BLOCKS, Pfam/Prodom, Database search engines, Entrez , SRS. **2. Overview/concepts in sequence analysis**: Pairwise sequence alignment algorithms, Scoring matrices for Nucleic acids and proteins, Database Similarity Searches – BLAST, FASTA Multiple sequence alignment, PRAS, CLUSTALW. **3. Structural biology and molecular modeling**: Proteins - 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. Principles of protein folding and methods to study protein folding. Macromolecular interactions, Protein-Protein, Protein-Nucleic acids, Protein-carbohydrates. Introduction to Molecular modelling methods. **4. Phylogenetic analysis:** Alignment, tree building and tree evaluation, Comparison and application of Unweighted Pair Group Method with Arithmetic Mean (UPGMA), Neighbour Joining (NJ), Maximum Parsimony (MP), Maximum Likelihood (ML) methods, Bootstrapping, Jackknife; Software for Phylogenetic analysis. DNA barcoding: Methods tools and databases for barcoding across all species, Applications and limitations of barcoding, Consortium for	4 h 3h 4h 4h

	Barcode of Life (CBOL) recommendations, Barcode of Life Database (BOLD). **5. Analysis of DNA and Protein Microarrays:** Designing of oligo probes; Image processing and normalization; Microarray data variability (measurement and quantification); Analysis of differentially expressed genes; Experimental designs. **6. Application in drug design:** Chemical databases like NCI/PUBCHEM; Fundamentals of Receptor-ligand interactions; Structure-based drug design: Identification and Analysis of Binding sites and virtual screening; Ligand based drug design: Structure Activity Relationship – QSARs & Pharmacophore; in silico predictions of drug activity and ADMET.	4h 5h
Learning Outcomes:	Student will be able to: 1) Develop an understanding of basic theory of computational tools. 2) Gain working knowledge of these computational tools and methods. 3) Appreciate their relevance for investigating specific contemporary biological questions.	
Pedagogy:	Lectures/Tutorials/Seminars/Assignment/Self study	
References/Readings:	1. Andrew Leach. 2001. Molecular Modeling: Principles and Applications, Prentice Hall. 2. Attwood, T. K. and Parry-Smith, D. J. 2001. Introduction to Bioinformatics Delhi. Pearson Education (Singapore) Ptd. Ltd 3. 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 4. 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. 5. Dov Stekel, (2003); Microarray Bioinformatics; Cambridge University Press 6. Fasman, G.D. 1989. Prediction of protein structure and the principles of protein conformation. New York. Plenum Press. 7. 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. 8. Gimona, G. Cesareni and Yaffe, M. Sudol (EDS.). 2004. Modular protein domains, USA, Wiley-vch Verlag gmbh & co. 3-527-30813-X . 9. Gundertofte, K. and Jorgensen, F.S. 2000. Molecular modelling	

	and prediction of bioactivity, New York. Kluwer Academic Publishers. 10. J. bajorath 2004. Chemoinformatics: Concepts, Methods, and Tools for Drug Discovery (Methods in Molecular Biology), Humana Press 11. Mount, David. 2004. Bioinformatics: Sequence and Genome Analysis. New York, Cold Spring Harbor Laboratory Press. 12. Philip E. Bourne and Helge Weissig. 2003. Structural Bioinformatics - Methods of biochemical Analysis V. 44. New Jersey. Wiley-Liss 13. Rastogi, S.C., Mediratta, N. and Rastogi. P. 2004. Bioinformatics, methods and applications, genomics, proteomics and drug discovery, Prentice hall of India, pvt. Ltd., New Delhi. 14. Stephen Misener and Stephen Krawetz. 2004. Bioinformatics, methods and protocols, methods in molecular biology, Volume 132, Humana Press, New Jersey, Third Indian reprint 15. Webster, D. M. Ed. 2000. Protein structure prediction: methods and protocols, Totowa Humana Press, 2000. **Public domain database/tools/resources** DBGET-http://www.genome.jp/dbget/ LinkDB-http://www.genome.jp/dbget/linkdb.html Fgeneshttp://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 Explorerhttp://www.umass.edu/microbio/chime/pe_beta/pe/protexpl /f rntdoor.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/	

Programme: M.Sc. (Botany)
Course code: BOO-124
Title of the Course: Lab in Bioinformatics
Number of Credits: 1
Effective from AY: 2020-21

Prerequisite for the Course:	Basic knowledge of biochemistry and molecular biology, computers and Internet, biodiversity and genomics.	
Objective:	Provide students with practical experience of use of common computational tools and databases which facilitate investigation of molecular biology and evolution-related concepts. To train the students in modern areas of biological analysis.	
Content:	1. Exploring NCBI database, PUBMED and GenBank databases, EBI server and searching the EMBL Nucleotide database, Entrez, SWISSPROT & UniProtKB 2. Use of scoring matrices, Pair-wise local alignments of protein and DNA sequences using Smith-Waterman algorithm and interpretation of results. 3. 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. 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. 5. Search and retrieval: genomic and OMIM data at NCBI server, Interpreting DNA and Protein microarray data. 6. Use of gene prediction methods (GRAIL/Genscan,/Glimmer), various primer designing and restriction site prediction tools. 7. Use of different protein structure prediction databases (PDB, SCOP, CATH). 8. Exploring and using the derived databases: PROSITE, PRINTS, BLOCKS, Pfam and Prodom for pattern searching, domain searches, etc.) 9. Construction and study of protein structures using RASMOL/Deepview/PyMol. Homology modelling of proteins. Use of tools for mutation and analysis of protein structures. 10. Phylogenetic analysis of protein and nucleotide sequences, tree building, databases for barcoding.	2h 1 h 1h 1h 1h 1h 1h 1h 1h 2h

Learning Outcomes:	Student will be able to: 1) Develop an understanding of basic theory of computational tools. 2) Gain working knowledge of these computational tools and methods. 3) Appreciate their relevance for investigating specific contemporary biological questions.	
Pedagogy:	Internet based tools, hands on and group exercises, mini projects, videos, moodle guided exercises, videos, expert lectures, industrial visits, seminars.	
References/Readings:	1. Andrew Leach. 2001. Molecular Modeling: Principles and Applications, Prentice Hall. 2. Attwood, T. K. and Parry-Smith, D. J. 2001. Introduction to Bioinformatics Delhi. Pearson Education (Singapore) Ptd. Ltd 3. 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 4. 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. 5. Dov Stekel, (2003); Microarray Bioinformatics; Cambridge University Press 6. Fasman, G.D. 1989. Prediction of protein structure and the principles of protein conformation. New York. Plenum Press. 7. 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. 8. Gimona, G. Cesareni and Yaffe, M. Sudol (EDS.). 2004. Modular protein domains, USA, Wiley-vch Verlag gmbh & co. 3-527-30813-X . 9. Gundertofte, K. and Jorgensen, F.S. 2000. Molecular modelling and prediction of bioactivity, New York. Kluwer Academic Publishers. 10. J. bajorath 2004. Chemoinformatics: Concepts, Methods, and Tools for Drug Discovery (Methods in Molecular Biology), Humana Press 11. Mount, David. 2004. Bioinformatics: Sequence and Genome Analysis. New York, Cold Spring Harbor Laboratory Press. 12. Philip E. Bourne and Helge Weissig. 2003. Structural Bioinformatics - Methods of biochemical Analysis V. 44. New Jersey. Wiley-Liss 13. 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. 14. Stephen Misener and Stephen Krawetz. 2004. Bioinformatics, methods and protocols, methods in molecular biology, Volume 132, Humana Press, New Jersey, Third Indian reprint 15. Webster, D. M. Ed. 2000. Protein structure prediction: methods and protocols, Totowa Humana Press, 2000. **Public domain database/tools/resources** DBGET-http://www.genome.jp/dbget/ LinkDB-http://www.genome.jp/dbget/linkdb.html Fgeneshttp://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 Explorerhttp://www.umass.edu/microbio/chime/pe_beta/pe/protexpl/f rntdoor.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/	

Programme: M. Sc. (Botany)
Course Code: BOO-125
Title of the Course: Oenology (Wine Science and Technology)
Number of Credits: 1
Effective from AY: 2020-21

Prerequisites for the course:	Basic knowledge of fermented beverages and their cultural role.	
Objective:	strongly backed by local winemakers and industries and tourism department and appreciated by NAAC team in 2014 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.	
Content:	1. Overview of Enology, contrast between ancient and modern methods of wine making. 2. Viticulture and Grape species. 3. Wine Types and Styles, Wine Regions and Terroir, the Indian wine scene. 4. Harvesting and processing of grapes and other fruits. 5. Sources of contamination in wine making, Sanitation and Sterilization. 6. Scales of winemaking, microvinification, Materials and supplies used in wine making. 7. Chemistry and cell biology of fermentations with yeast and bacteria. 8. Fermentation Processes, Post-Fermentation. 9. Wine Analysis, Chemical Components of Wine, Biochemical Reactions in Fermentation. 10. Wine Acids, Aroma compounds (Terpenes), Color and FlavorCompounds (phenolics, Tannins). 11. Sensory evaluation and Quality control in wine making. 12. Wine bottling, corking, packaging and marketing.	**1hour** **1hour** **1hour** **1hour** **1hour** **1hour** **1hour** **1hour** **1hour** **1hour** **2hours demo**
Pedagogy:	Lectures/ Tutorials/Assignments/Seminars/Videos/Expert Lectures/Industrial visits/Moodle based guidance/ Self-study	
References/Readings	1. **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. 2. **Amerine, M. A. and Roessler, E. B.** 1983. Wines: Their sensory evaluation. WH Freeman & Co. San Francisco. 3. **Amerine, M. A. and Singleton, V. L.** 1977. Wine: An Introduction to the Wines of the World, 4. Grape Cultivation, Techniques of Wine-making, and How to evaluate and Enjoy Wines. University of California Press. 5. **Boulton, R. B., Singleton, V. L., Bisson, L. F. and Kunkee, R. E.** 1996. Principles and Practices of Winemaking. Chapman and Hall, New York. 6. **Fleet, G. H.** 1993. Wine Microbiology and Biotechnology. Harwood Academic Publishers, Chur. 7. **Fugelsang, K. C.** 1997. Wine Microbiology. Chapman & Hall, New York. 8. **Iland, P, Ewart, A. and Sitters, J.** 1993. Techniques for Chemical Analysis and Stability	

Tests of Grape Juice and Wine. Patrick Iland Wine Promotions, PO Box 131, Campbelltown, South Australia 5074.

9. **Iland, P.** 1991. An Introduction to Wine: A Guide to the Making, Tasting, and Appreciation of Wine. Patrick Iland Wine Promotions, PO Box 131, Campbelltown, South Australia 5074.
10. **Jackson, R. S.** 2000. Wine Science: Principles, Practice, Perception.Second Edition. Academic Press, Inc., 525 B Street, Suite 1900, San Deigo, California.
11. **Linskens, H. F. andJackson, J. F.** 1988. Wine Analysis: Modern Methods of Plant Analysis. New series volume 6. Springer Verlag.
12. **Ough, C. S.** 1991. Winemaking Basics. Food Products Press, New York.
13. **Ough, C. S. and Amerine, M. A.** 1988. Methods for Analysis of Musts and Wines. Second Edition. **J. Wiley & Sons**, New York.
14. **Ribereau-Gayon, P., D. Dubourdieu and B. Doneche, A. Lonvaud**. 2000. Handbook of Enology Volume 1: Microbiology of Wine and Vinifications. John Wiley & Sons, New York.
15. **Ribereau-Gayon, P., Y. Glories, A. Maugean and D. Dubourdieu.** 2000. Handbook of Enology Volume 2: Microbiology of Wine, The Chemistry of Wine Stabilization and Treatments. John Wiley & Sons, New York.
16. **Robinson, J.** 1994. The Oxford Companion to Wine. Oxford University Press, Oxford, New York.
17. **Schahinger, G. and Rankine, B.** 1992. Cooperage for Winemakers: A manual on the construction, maintenance, and use of oak barrels. Ryan Publications, Adelaide, South Australia.
18. **Storm, D. R.** 1997. Winery utilities: planning, design and operation. Chapman & Hall, New York.
19. **Vine, R. P.** 1981. Commercial Winemaking, Processing and Controls. AVI Publishing Co., Westport, CT.
20. **Vine, R. P.** E. M. Harkness, T. Browning, C. Wagner, and B. Bordelon. 1997. Winemaking: from grape growing to marketplace. Chapman & Hall, New York.
21. **Waterhouse, A. L. and S. E. Ebeler**. 1998.

	Chemistry of Wine Flavor. American Chemical Society, Washington, D.C. 22. **Zoecklein, B. W., Fugelsang, K. C., Gump, B. H. and Nury, F. S.** 1990. Production Wine Analysis. An AVI book. 23. **Zoecklein, B. W., Fugelsang, K. C., Gump, B. H. and Nury, F. S.** 1995. Wine Analysis and Production. Chapmann & Hall, New York, NY. **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	
Learning Outcomes	1. To be able to understand international trends in production and marketing of wines. 2. Ability to appreciate the role of wine in culture, religion, industry and economy. 3. Ability to work as an oenological consultant. 4.Better prospects in tourism industry serving wines.	

Programme: M. Sc. (Botany)
Course Code: BOO-126
Title of the Course: Lab in Oenology (Wine Science and Technology)
Number of Credits: 1 (24 hours)
Effective from AY: 2020-21

Prerequisites for the course:	Basic knowledge of botany, grapes, fruits, fermentation processes, microbiology, general interest in food and beverages sector. This course is not intended for those who see alcoholic beverages as taboo.	
Objective:	To impart training in benchtop production of fruit wines and in service, testing and appreciation of various wines and knwoedge of global wine brands in order to make students employable as oenlogists in hospitality or wine production sector	

Content:	1. Examination of different commercial strains of wine yeasts 2. Microscale production of grape wine 3. Monitoring of fermentation parameters of grape wine Use of refractometer and hydrometer 4. Benchtop production and monitoring of wines from fruit juices 5. Organosensory evaluation of grape and non grape fruit wines. 6. Report on wine brands and wine marketing. ***For demos**: visit to be organised to local wineries/fermentation units: Le Meredien Distillry & Winery, Vinicola,Margao; Cazcar, Nanoda and others wine tasting sessions.	**2 hours** **4 hours** **4 hours** **10 hours** **2 hours** **2 hours**
Pedagogy:	Lab Exercizes, Demos, Field visits, Industrial visits, Expert Lectures, Videos.	
References/Readings	1. **Boulton, R. B., Singleton, V. L., Bisson, L. F. and Kunkee, R. E.** 1996. Principles and Practices of Winemaking. Chapman and Hall, New York. 2. **Fleet, G. H.** 1993. Wine Microbiology and Biotechnology. Harwood Academic Publishers, Chur. 3. **Fugelsang, K. C.** 1997. Wine Microbiology. Chapman & Hall, New York. 4. **Iland, P, Ewart, A. and Sitters, J.** 1993. Techniques For Chemical Analysis and Stability Tests of Grape Juice and Wine.Patrick Iland Wine Promotions, PO Box 131, Campbelltown, South Australia 5074. 5. **Iland, P.** 1991. An Introduction to Wine: A Guide to the Making, Tasting, and Appreciation of Wine. Patrick Iland Wine Promotions, PO Box 131, Campbelltown, South Australia 5074.	
Learning Outcomes	1. Ability to understand global wine sector, wine market and wine brands. 2. Ability to define a terroir. 3. Ability to analyse global wine trade trends. 3. Ability to produce fruit wines on small scale. 4. Ability to do sensory evaluation of wines. 5. Ability to work as a trainee oenologist. 6. Ability to work as wine journalist or columnist. 7. Ability to join hospitality sector as an expert on elite brands of wines. 8. Better prospects to take advanced courses as vintners or sommeliers.	

Programme: M. Sc. (Botany)
Course Code: BOO-127
Title of the Course: Mine Wasteland Management.
Number of Credits: 2
Effective from AY: 2020-21

Prerequisites for the course:	Should have studied B. Sc. Botany. It is assumed that students have a basic knowledge of Environmental Biology and Ecology.	
Objective:	To impart training to students on various aspects of mine waste reclamation strategies.	
Content:	**1. Contaminated land:** Sources of contamination, Open cast and underground mining; Production of wastes – reject dumps and tailings; Mineral resources - use (including economic impacts) and exploitation; beneficial uses of wastes; Environmental issues, Problems (man induced landslides, soil erosion, land degradation, pollution of water bodies and agricultural fields, air pollution and health risks); Flora of mine wastelands (natural and managed). **2. Characteristics of wastes** – Physical characteristics – texture, bulk density, specific gravity, porosity, air content, field capacity, wilting coefficient, water holding capacity, colour, pH, C:N ratio, compaction; Chemical characteristics. **3. Remediation of contaminated lands** – Physical, chemical and biological methods; soil washing, soil vapour extraction (SVE), soil flushing, excavation, isolation/encapsulation, thermal desorption, land farming, biopiles, bioslurry system, bioventing, stabilization, vitrification, phytoremediation. Mycorrhizoremediation. **4. Phytoremediation strategies** – Phytoextraction and phytomining, rhizofiltration, phytostabilization, phytovolatilization, phytodegradation, rhizodegradation, phytodesalination. **5. Elemental accumulation in plants** – heavy metals, heavy metal toxicity, accumulation of elements, phytosiderophores, heavy metal accumulation. **6. Selection of Plant species**: Factors affecting plant selection, plant species for reclamation, monocultures v/s polycultures; native v/s exotic plants; plant propagation. **7. Conditioning of waste**: organic material; Fly ash, zeolites, neutralizing materials; fertilizers; PSB's,	4 hours 2 hours 3 hours 2 hours 2 hours 2 hours 3 hours 3 hours 2 hours

	rhizobia, PGPR, mycorrhizae, co-remediation. **8. Land use options**: success of reclamation, prospective land use; frame work for land evaluation, land suitability classification; land quality and characteristics; land uses. **9. Biotechnological approaches to phytoremediation**: genetic engineering in phytoremediation, tissue culture plants for phytoremediation. **10. Geotourism in mining sites.**	1 hour
Pedagogy:	Lectures/Assignments.	
References/Readings	hi, R. S. Singh and C. D. Hills2016 Reclamation of Mine-Ecosystem Recovery. John Wiley & Sons, Ltd. S. K. Karma 2001 Wasteland Management and Environment, Scientific Publishers. C. Bini and M. Pashkevich 2017 Assessment, Restora ion of Mining Influenced Soils. Academic Press. N.S. Bolan, M.B. Kirkham, Y.S. Ok 2017 Spoil to Soil: Mine Site Rehabilitation and Revegetation, First Edition, CRC Press R E Hester, R M Harrison 1994 Mining and its Environmental Impact. Royal Society of Chemistry, UK. Urbanska K. M., Webb N. R., Edwards P.J. 1997. Restoration Ecology and Sustainable Development. Cambridge University Press, Cambridge. Mining and environment in India. 1988 H.R. Publishers, Nanital. B. B. Dhar 2000 Mining and environment. APH Publishers, Nanital.	
Learning Outcomes	Upon completion of this course, the students gain expertise in mine waste reclamation. This will enable them to take up consultancy studies.	

Programme: M. Sc. (Botany)
Course Code: BOO-128
Title of the Course: Seed Science and Technology.
Number of Credits: 2
Effective from AY: 2020-21

Prerequisites for the course:	Should have studied B. Sc. Botany. It is assumed that students have a basic knowledge of seed biology.	
Objective:	To facilitate deeper understanding of various aspects of seed science and technology.	

Content:	**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.	2 hours
	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.	3 hours 3 hours
	3. Seed cleaning equipment and their functions: 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.	4 hours
	4. Seed treatment: Types of seed treatment, seed treating formulations and equipments, seed disinfestations, identification of treated seeds; packaging: principles, practices and materials; bagging and labeling.	7 hours
	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.	1 hours 1 hours
	6. Seed germination methods; TTC test; Embryo excision method.	1 hours
	7. Seed Certification: Objectives of seed certification; legal status and phases of seed certification; formulation, revision and publication of seed certification standards.	2 hours
	8. Field Inspection: Method of inspection; Post harvest inspection; specifications for tags and labels.	
	9. Seed Legislation and Seed Law Enforcement: Seed Legislation in India; Regulatory Legislations; Seed Law Enforcement; Seed Control Order, 1983; The Plant Varieties Act.	
Pedagogy:	Lectures/Assignments.	

References/Readings	**1. Agarwal R.L.** 2007. Seed Technology. Oxford & IBH. **2. Agrawal P.K. and Dadlani M.** 1992. Techniques in Seed Science and Technology. 2nd Ed. South Asian Publications. **3. Agrawal P.K.** 1993. Handbook of Seed Testing. Ministry of Agriculture, GOI, New Delhi. **4. Copland L.O. and McDonald M.B.** 1996. Principles of Seed Science and Technology. Kluwer. **5. ISTA** 2006. Seed Testing Manual. ISTA, Switzerland. **6. Martin C. and Barkley D.** 1961. Seed Identification Manual. Oxford & IBH. **7. Tunwar N.S. and Singh S.V.** 1988. Indian Minimum Seed Certification Standards. Central Seed Certification Board, Ministry of Agriculture, New Delhi.	
Learning Outcomes	Ability to work in seed banks and plant nurseries. Ability to educate farmers and seed producers. Ability to run seed distribution outlets. Ability to work as market watchdogs to detect spurious seeds. Ability to work as seed collectors.	

Programme: M. Sc. (Botany)
Course Code: BOO-129
Title of the Course: Lab in Seed Science and Technology.
Number of Credits: 1
Effective from AY: 2020-21

Prerequisites for the course:	Should have studied B. Sc. Botany. It is assumed that students have a basic knowledge of seed biology.	
Objective:	To facilitate deeper understanding of various aspects of seed science and technology.	
Content:	1. Identification of seeds of weeds and crops. 2. Physical purity analysis of samples of different crops. 3. Estimation of seed moisture content (oven method). 4. Seed dormancy breaking methods requirements for conducting germination test. 5. Seed germination testing in different agri-horticultural crops. 6. Viability testing by tetrazolium test in different crops. 7. Seed and seedling vigour tests. 8. Effect of drying temperature and duration on seed germination. 9. Testing coated/pelleted seeds. 10. Study of orthodox, intermediary and recalcitrant seeds.	2 hours 2 hours 2 hours 2 hours 4 hours 2 hours 2 hours 2 hours

	11. Global seed germplasm resources and their conservation.	2 hours 2 hours 2 hours
Pedagogy:	Practicals	
References/Readings	**8. Agarwal R.L.** 2007. Seed Technology. Oxford & IBH. **9. Agrawal P.K. and Dadlani M.** 1992. Techniques in Seed Science and Technology. 2nd Ed. South Asian Publications. **10. Agrawal P.K.** 1993. Handbook of Seed Testing. Ministry of Agriculture, GOI, New Delhi. **11. Copland L.O. and McDonald M.B.** 1996. Principles of Seed Science and Technology. Kluwer. **12. ISTA** 2006. Seed Testing Manual. ISTA, Switzerland. **13. Martin C. and Barkley D.** 1961. Seed Identification Manual. Oxford & IBH. **14. Tunwar N.S. and Singh S.V.** 1988. Indian Minimum Seed Certification Standards. Central Seed Certification Board, Ministry of Agriculture, New Delhi.	
Learning Outcomes	Ability to carry out seed germination tests. Ability to work in seed testing labs and commercial seed companies.	

Programme: M. Sc. (Botany)
Course Code: BOO-221
Title of the Course: Plant-Animal Interactions
Number of Credits: 4
Effective from AY: 2020-21

Prerequisites for the course:	Should have basic degree in biology or a student of Masters Programme in any of the life science areas	
Objectives:	Plants and Animals form major groups of living organisms in the World. Myriads of interactions between them are the drivers of evolution. Compartmentalization of biological sciences into various disciplines, viz. Botany, Zoology, Microbiology etc., has taken away the opportunities of 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.	
Content:	**1. Diversity and Plant-Animal interactions:** Mutualism, Antagonism, Commensalism, Competition, Multi-trophic level	6 Hours

	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.	
	2. Pollination Biology: Importance of cross 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. Foraging theory, foraging strategies and time-niche strategies.	8 Hours
	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.	7 Hours
	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. Effect of herbivores on plant communities – The Janzen-Connell hypothesis. Effect of herbivores on plant communities. Hormonal interaction between plants and animals.	9 Hours 5 Hours
	5. Ant-plant interactions: Ant-plant symbioses – mutualism and non-mutualism (herbivores, harvesting ants, granivores and leaf-cutting). Ants as primary and secondary seed dispersers; pollination by ants; ant-fed plants and ant gardens; canopy ants; effects of harvesters on vegetation. Fungus growers.	3 Hours
	6. Carnivorous plants: Mechanisms of interaction between carnivorous plants and animals, trap mechanisms; nutritional benefits of carnivory.	7 Hours
	7. **Plant communities as animal habitats:** Adaptations,	

	ecological segregation within and between habitats; mechanisms of habitat selection, effects of plants on animal spacing and aggression. Impact of invasive plants on native plant-animal interactions. Plant-animal interactions in agricultural ecosystems. 8. **Climate change** and break down of plant-animal interactions; impact on community, diversity, productivity and livelihood.	3 Hours
Pedagogy:	Lectures/ tutorials/assignments/self-study/field observations	
References/ Readings	**Abrahamson, W.G.** (ed.). 1989. Plant-animal interactions. McGraw-Hill Book Company, NY. **Burslem, D., M.Pinard and S.Hartley.** 2005. Biotic Interactions in the Tropics: Their Role in the Maintenance of Species Diversity. Cambridge University Press. **Crawley, M.J.** 1986. Plant Ecology. Blackwell Scientific Publications. **Endress, P.K.** 1994. Diversity and Evolutionary biology of tropical flowers. Cambridge University Press. **Harborne, J.B.** 1988. Introduction to ecological biochemistry. Academic Press. **Herrera, Carlos M. and Olle Pellmyr** (eds.). 2002. Plant Animal Interactions: An Evolutionary Approach. Blackwell Science. **Holldobler, B. and Wilson, E.O.** 1990. The Ants. Springer-Verlag. **Lloyd, D.G. and Barret, S.C.H.** 1996. Floral Biology: studies on Floral evolution in Animal pollinated plants. Chapman & Hall. **Price, P.W., T.M. Lewinsohn, G.W.Fernandes and W.W. Benson.** 1991. Plant-Animal Interactions: Evolutionary Ecology in Tropical and Temperate Regions. A Wiley-Interscience publication **Proctor, M., Yeo, P. and Lack, A.** 1996. The Natural History of Pollination. Harper Collins Publishers. **Richards, A.J.** 1986. Plant Breeding systems. George Allen & Unwin, London. **Schaefer, M.H. and G.D. Ruxton.** 2011. Plant-Animal Communication. Oxford University Press. **Seckbach, J. and Z. Dubinsky.** 2010. All Flesh Is Grass: Plant-Animal Interrelationships. Springer Science & Business Media. **Smith, R.L.** 1990. Ecology and field biology. Harper Collins	

	Publishers. **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. **Willmer, Pat.** 2011. Pollination and Floral Ecology. Princeton University Press	
Learning Outcomes	Would have understood intricate evolutionary relationships between plants and animals including their interdependence. Should have learnt the role of herbivory in phytochemical evolution and its importance in plant based drugs. Would have understood the importance of multicultural practices in the control of pests, organic farming and reduction of chemical pesticides. Able to appreciate the ecosystem services through these plant-animal interactions. Understand the effect of climate change on these interactions, conservation and survival of human species.	

Programme: M. Sc. (Botany)
Course Code: BOO-224
Title of the Course: Post Harvest Technology for Fruit Crops.
Number of Credits: 2
Effective from AY: 2020-21

Prerequisites for the course:	Knowledge of basic Botany and fruit crops at UG level.	
Objective:	The paper deals postharvest technology and processing of various fruit crops. Maturity indices, postharvest physiology, various storage and packaging methods, principles and processing of various fruits, value added products and postharvest diseases are discussed.	
Content:	1. Introduction to post-harvest technology, tropical fruits, major fruit crops of Goa, post-harvest and processing status of Kokum (*Garcinia indica*), maturity indices, harvesting practices for specific market requirements, influence of pre-harvest practices. **2.** Enzymatic and textural changes, respiration, transpiration, temperature, physiology and biochemistry of fruit ripening, ethylene evolution and	**5 hours** **5 hours**

	ethylene management, factors leading to post-harvest loss, pre-cooling. **3.** Treatments prior to shipment - chlorination, waxing, chemicals, bio-control agents and natural plant products. Methods of storage-ventilated, refrigerated, modified atmospheric storage (MAS), controlled atmospheric storage (CAS), physical injuries and disorders. **4.** Packing methods and transport, principles and methods of preservation, food processing, canning, fruit juices, beverages, pickles, jam, jellies, candies. **5.** Dried and dehydrated products, nutritionally enriched products, fermented fruit beverages, packaging technology, processing waste management, food safety standards.	**5 hours** **5 hours** 4 hours
Pedagogy:	Lectures/Moodle/ Tutorials/Assignments/Seminars/Self-Study	
References/Readings	1. **Sudheer K. P and Indira V.** 2007. Post Harvest Technology of Horticultural Crops. New India Publishing Agency, New Delhi. 2. **Patil R. T., Desh Beer Singh and Gupta R. K.** 2009. Post Harvest Management of Horticultural Produce Recent Trends. Daya Publishing House, Delhi. 3 **Debbie Rees, Graham Farrell and John Orchard** 2012. Crop Post-Harvest: Science and Technology. Wiley-Blackwell, UK. 4. **Bhutani R. C.** 2003. Fruit and Vegetable Preservation. Biotech Books Publishing House, Delhi. 5. **Chadha K. L and Pareek O. P.** 1996. Advances in Horticulture. Vol. IV. Malhotra Publishing House. Delhi. 6. **Haid N. F and Salunkhe S. K.** 1997. Post Harvest Physiology and Handling of Fruits and Vegetables. Grenada Publishers, USA. 7. **Mitra S. K.** 1997. Post Harvest Physiology and Storage of Tropical and Sub-tropical Fruits. CABI, UK. 8. **Ranganna S.** 1997. Hand Book of Analysis and Quality Control for Fruit and Vegetable Products. Tata McGraw-Hill, Dehli. 9. **Willis R, Mc Glassen WB, Graham D & Joyce D.** 1998. Post Harvest. An Introduction to the Physiology and Handling of Fruits, Vegetables and Ornamentals. CABI, UK. 10. **Wim Jongen** 2002. Fruit and vegetable processing. Improving quality. Woodhead Publishing Ltd.,	

	Cambridge, UK and CRC press, New York, USA. 11. **Mandal R. C.** 2007. Cashew Production and Processing Technology. AGROBIOS (India), Jodhpur.	
Learning Outcomes	1. Being able to apply the knowledge of postharvest technology and processing to various fruit crops. 2. Understanding maturity indices, postharvest physiology, various storage and packaging methods to various situations and applications. 3. Being able to apply the principles and processing of various fruits, value added products and postharvest diseases to other fruit crops.	

Programme: M. Sc. (Botany)
Course Code: BOO - 225
Title of the Course: Ethnobotany
Number of Credits: 2
Effective from AY: 2020-21

Prerequisites for the course:	Should have studied B. Sc. Botany.	
Objective:	To impart ethnobotanical knowledge, methods of collecting ethnobotanicl data and commercial use of traditional knowledge is given in this paper.	
Content:	**1.** 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. **2.** Distribution of tribes in India. Knowledge of tribes of Konkan, Goa and Kanara; Ethnobotanical works on these tribes. **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 andquestionnaire methods, choice of resource persons. **4**. Ethnobotanical knowledge and communities: Ethnobotanical classification; Folk Taxonomy of Plants. Non timber Forest Produce (NTFP) and livelihood. Sustainable harvest & value addition. Ethnomycology.	**3 hours** **2 hours** **5 hours** **5 hours**

	Conservation and Community development. **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. **6.** Traditional knowledge (TK) in relation to Intellectual Property Rights and Biopiracy. Equitable Benefit sharing models of the world. **7.** Ethnobotany and peoples biodiversity register.	**5 hours** **3 hours** **1 hour**
Pedagogy:	Lectures/ Tutorials/Assignments/Self-Study.	
References/Readings	**1.Alexiades, M.** 1996**.** Selected guidelines for ethnobotanical research: A field manual. New York: NewYork Botanical Garden. **2.Apte, T.** 2006**.** Intellectual Property Rights, Biodiversity and Traditional Knowledge. Kalpavriksh, Grain &IIED, Pune / New Delhi. **3.Begossi, A.** 1996**.** Use of ecological methods in ethnobotany. Economic Botany 50 (3): 280–89. **4.Balee W. L.** 2003. Footprints of the Forests. Bishen Singh Mahendar Pal Singh, Dehra Dun, India. **5.Balick, M. and P. A. Cox.** 1996. Plants, People, and Culture: The Science of Ethnobotany. Scientific American Library, New York. **6.Cotton, C. M.** 1997. Ethnobotany – Principles and Applications. John Wiley and Sons Limited. New York, USA. **7. CSIR.** 1940-1976. Wealth of India. A Dictionary of Raw Materials and Industrial Products - Raw Materials.Vol.1-11. CSIR Publication & Information Directorate. New Delhi.	
Learning Outcomes	1. To enable students to understand the importance of traditional knowledge systems in ethnobotany important for GIP and pharma industry. 2. Acquire ability to interact with triabla and other medicinal practioners and people javing spcial knowledge of medicinal and other useful plants. 3. To develop career with NGOs involved in documenting tribal knowledge.	

Programme: M. Sc. (Botany)
Course Code: BOO-226
Title of the Course: Remote Sensing: Techniques and Applications
Number of Credits: 3
Effective from AY: 2020-21

Prerequisites for the course:	Science back ground.	
Objectives:	Thousands of Remote Sensing satellites are circling the globe and continuously sending digital imageries. They have enormous application potential. However, technological advancement in this sphere is not duly supported by the trained human power to process and interpret the data. This introductory course deals with various aspects of Remote Sensing and their applications in forestry, ecology and Environment Impact Assessment.	
Contents:	1. Principles and basic concepts of Remote Sensing: Principles of Electromagnetic Radiation; Interactions with Earth Surface Materials; Atmospheric Effects and atmospheric windows. 2. Characteristics of Remotely Sensed Data: Spatial Resolution, Spectral Resolution, Radiometric Resolution, Temporal Resolution. 3. Remote Sensors: Electro-Optical Sensors, Across-Track Scanning Systems, Linear-Array (Along-Track) Scanning Systems, Thermal IR Sensors, Microwave and Imaging Radar Sensors, Lidar. 4. Digital Image Processing and Analysis: Feature Extraction, Radiometric Corrections, Geometric Corrections, Atmospheric Correction; image enhancement, extraction of information and classification; elements of image interpretation; Image Classification (supervised and unsupervised). Hyperspectral Image Analysis. 5. Contemporary Satellites and Sensors: Overview; Resourcesat-2 (AWiFS, LISS-III, LISS-IV, S-AIS); Landsat 8 [Operational Land Imager (OLI), Thermal InfraRed Sensor (TIRS)]; historical data. 6. Applications in Forestry and Ecology: Principles of image interpretation in forestry and ecology; principles	4 Hours 4 Hours 5 Hours 7 Hours 4 Hours 12 Hours

	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.	
Pedagogy:	Lectures/ tutorials/assignments/self-study	
References/ Readings	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. George Joseph and C.Jeganathan, 2018. Fundamentals of Remote Sensing. Third Edition. Universities Press (India) Private Limited, Hyderabad, India. 2018. Lillesand, T.M., Ralph W Kiefer, Jonathan W Chipman, 2004. Remote Sensing and Image Interpretation. John Wiley & Sons Rees W. G. 2001. Physical Principles Of Remote Sensing. Cambridge University Press. Richards, John A., Jia, Xiuping, 2006. Remote Sensing Digital Image Analysis: An Introduction (4th ed.). Springer. Sabnis, F. F. 1996. Remote Sensing: Principles and Interpretations. W H Freeman and Company 1996. Weng, Qihao, 2011. An Introduction to Contemporary Remote Sensing. McGraw Hill Professional, 2011.	
Learning Outcomes	Clear understanding of the basics of Remote Sensing (RS). Theoretical base for processing and analysing the RS data. Ability to choose the type of RS data required for a given application. Methodological strength in applying the data in forestry, ecology and EIA.	

Programme: M. Sc. (Botany)
Course Code: BOO-227
Title of the Course: Lab in Remote Sensing
Number of Credits: 1
Effective from AY: 2020-21

Prerequisites for the course:	Basic course in Remote Sensing (either attended earlier or attending simultaneously)	
Objectives:	Learn to process the Remotely Sensed data and interpret it.	
Contents:	1. Visual Interpretation of False colour Multi Band Imagery. (1) 2.Downloading free RS data (1) 3. Exploration of single band and multiple band images (1) 4. Contrast enhancement, calculation of histogram, linear stretching, and histogram equalization. (1) 5. Spatial enhancement – applying filters for enhancement. (1) 6. Geo referencing of digital images (2) 7. NDVI analysis and comparison with original data for interpretation. (1) 9. Image classification – Density slicing, interactive slicing. (1) 10. Unsupervised classification. (1) 11. Supervised classification. (1) 12. Presentation of results after analysis. (1)	
Pedagogy:	Hands on learning through computer software and visual interpretation.	
References/ Readings	**ILWIS 3.0 User's Guide (https://www.itc.nl/ilwis/users-guide/)**	
Learning Outcomes	Will be able to process the image using software, extract information and interpret it. Skill in ecoinformatics and environmental management with potential for employment.	

Programme: M. Sc. (Botany)
Course Code: BOO-329
Title of the Course: Applied Phycology: Utilization and Management
Number of Credits: 3
Effective from AY: 2020-21

Prerequisites for the course:	Should have studied B. Sc. Botany.	
Objective:	To introduce the commercial applications of Algae and also their use in environmental management	
Content:	**1.Mariculture**: Scientific basis and Techniques of Mariculture Eucheuma, Porphyra and, Laminaria	**3**

	technique. Rafts used in Mariculture Seaweed cultivation in India **2. <u>Food and food products from Seaweeds</u>.** *Porphyra* as food: Cultivation and economics: Food and other uses, development of cultivation methods, present and future trends *Spirulina* as human food: Nutritional aspects. Economic and environmental aspects. Theraupetic applications, Harvesting wild populations, Village scale production, Microalgal nutraceuticals and their production Cultivated edible kelps: Edible products, kelp composition, kelp production methods, world production Some public health aspects of microalgal products. Pheophorbide, Microbial contamination, Extraneous materials, metals, organic compounds, Maintaining sanitary quality	**8**
	3. <u>Commercial production and application of algae</u>:Hydrocolloids : History, Chemistry production and Application, future aspects of alginates, Carrageenans, Agars. Hydrocolloid resources of India **Lipids and polyols** from microalgae History of microalgal lipid production research, Triaglycerotl, Hydrocarban, , carotenoids, polyols **Hydrogen production by algae:** water splitting Role of algae in hydrogen production, principles of photosynthetic hydrogen production, Bio-photolysis of water. **Products from fossil algae:** Diatomite-industrial mineral, Calcareous algal fossils and their products algal kerogen in petroleum and coal,	**8**
	4. <u>Algae in Environmental Management</u> **gae & Agriculture:** Free living cyanobacteria and algalization, *Azolla*, Microalgal soil conditioners, Microalgal plant growth regulation, Seaweed use in agriculture and horticulture **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 **<u>Harmful Aspects of Algae</u>** **arine dinoflagellates blooms**: dynamics and impacts:	**5**

	Bloom dynamics: Initiation, growth, maintenance, Termination, Ecological and Economic impacts: Negative & Positive impacts. Harmful algal blooms in India **Hazards of freshwater blue green algae**: (Cyanobacteria) 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 **6. <u>Algae in Future</u>:** **Algae in space:** Algae and life support systems; Algae and planetary biology, Future of algae in space. **Algal Transgenics and Biotechnology**	**8** **4**
<u>Pedagogy</u>:	Lectures/ Tutorials/Assignments/Self-Study/ Visit to Research laborartories.	
<u>References/Readings</u>	Alexander, I., Railkin 2004. Marine biofouling: colonization processes and defenses. CRC Press LLC Ayhan Demirbas. 2008. Biofuels: Securing the Planet's Future Energy Needs. Springer – Verlag London Limited Chapman, V, J. and Chapman, D.J. 1975. The algae, 2nd Edition, Mac. Millan Publ. Inc. New York Craig A. Grimes., Oomman 2008. Light, water, hydrogen: the solar generation of hydrogen by water. Springer Science + Business Media, LLC David M. Mousdale 2008. Biofuels: biotechnology, chemistry, and sustainable development. Taylor & Francis Group, LLC Dean, S. W., Guillermo Hernandez-Duque Delgadillo, James B. Bushman. 2000. Marine corrosion in tropical environments. American Society for Testing and Materials. Dey P. M. , Jeffrey B. Harborne 1997. Plant biochemistry, Academic Press Hans-Curt Flemming, P., Sriyutha Murthy., R. Venkatesan 2009. Marine and Industrial Biofouling.Springer Verlag	

	Berlin Heidelberg Press Harald W., Tietze. 1999. Spirulina Micro Food Macro Blessings, Harald W. Tietze Publisher Kevin G. Sellner. Physiology, Ecology, and Toxic Properties of Marine Cyanobacteria Blooms. 2009. American Society of Limnology and Oceanography Press Linda E. Graham., James M. Graham., Lee Warren Wilcox 2009. Algae. Benjamin Cummings West Conshohocken, P.D. Féron, 2001. Marine corrosion of stainless steels. Snippet view Oskar R. Zaborsky. 1998. Biohydrogen. Plenum Press, New York Robert Edward Lee. 1999. Phycology (SPIRULINA). Cambridge University Press Raina M. Maier., Ian L. Pepper., Charles P. Gerba. 2009. Environmental microbiology (SPIRULINA). Elsevier	
Learning outcome	1. Be able to understand the role of algae in the field of Biotechnology, Environmental monitoring etc 2. Have better prospects as researchers .	

Programme: M. Sc. (Botany)
Course Code: BOO-322
Title of the Course: Plant Biotechnology.
Number of Credits: 3
Effective from AY: 2020-21

Prerequisites for the course:	Basic knowledge of Biotechnology.	
Objective:	To impart recent knowledge in the field of Plant Biotechnology beneficial to economy and industry.	
Content:	**1. Plant Tissue Culture:** Totipotency; A brief history of plant tissue culture; Laboratory Organisation; Media Preparation, Cell Cultures (including Bergmann's plating technique). **2. Applications of Plant cell, tissue and organ cultures:** Applications in agriculture: improvement of hybrids, encapsulated cells, production of disease and stress	**6 hours** **2 hours**

	resistant plants. Applications in horticulture and Forestry; 3. **Applications in industries** – Production of secondary metabolites; use of bioreactors. **4. Micropropagation and somaclonal variation:** Clonal propagation or micropropagation; Mechanism of somaclonal variation, Applications. **5. Germplasm conservation:** Modes of Conservation, Cryopreservation: Methods of cryopreservation, cryobank, Pollen bank; Prospects in agricultural and forest biotechnology. **6. 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. **7. 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. **8. Transgenic Plants:** Selectable marker genes and their use in transformed plants; Transgenic plants for crop improvement; Molecular farming from transgenic plants; Bioethics in plant genetic engineering. **9. Gene transfer methods in plants:** *Agrobacterium* mediated gene transfer; selectable and scorable markers (reporter genes), agroinfection and gene transfer, DNA mediated gene transfer (DMGT); Methods of direct gene transfer. **10. Application of Biotechnology in Agriculture, Forestry and human welfare:** Marker assisted selection (MAS); Production of Biopesticides; Environmental and Enzyme biotechnology.	**2 hours** **3 hours** **4 hours** **6 hours** **6 hours** **2 hours** **2 hours** **3 hours**
Pedagogy:	Lectures/Assignments/Tutorials/Self study.	
<u>References/Readings</u>	**1. Aguilar Cristobel Noe** 2008. Food Science and Food Biotechnology in Developing countries. Asiatech Publishers Inc. **2. Prasad** 2008. Biotechnology in Sustainable Biodiversity and Food Security. India Book House Limited. **3. Vibha Dhawan** 2008. Biotechnology for Food and Nutritional Security. Teri Press. **4. Bhojwani, S. S. and Razdan, M. K.** 1997. Plant	

	Tissue Culture: Theory and Practice. Springer Publishers Netherlands. 5. **Rajmohan Joshi** 2006. Agricultural Biotechnology. Gyan Books. 6. **Kumar, H. D.** 2005. Agricultural Biotechnology. Daya Publishing House. 7. **Gautam, H.** 2006. Agricultural & Industrial Applications of Bio-technology. Rajat Publication. 8. **Harikumar, V.** S. 2006. Advances in Agricultural Biotechnology. Regency Publishers. 9. **Bhavneet Kaur, C.P. Malik andChitra Wadhwani** 2008. Current Topics in Biotechnology. M.D. Publications, New Delhi. 10. **Dubey, R. C.** 2009. A text book of Biotechnology. S. Chand & Co. Ltd. New Delhi.	
Learning Outcomes	Able to work in Plant tissue culture laboratory, in Pharmaceutical and ayurvedic drug industries, research laboratories and plant germplasm banks.	

Programme: M. Sc. (Botany)
Course Code: BOO- 323
Title of the Course: Lab in Plant Biotechnology.
Number of Credits: 1 (24 hours)
Effective from AY: 2020-21

Prerequisites for the course:	Practical knowledge of Plant Biotechnology.	
Objective:	To train the studetns in practical aspects of plant biotechnology with special emphasis on somatic embryogenesis and organogenesis.	
Content:	**(Any practical's of total 30 hours duration)** 1. Familiarizing with various physical and chemical sterilization techniques. 2. Preparation Murashige and Skoog (MS) Media. 3. Preparation of explants and inoculation. 4. Leaf and node culture. 5. Stem culture. 6. *In vitro* embryo culture of *Pisum sativum*. 7. Seed culture. 8. Anther culture using Datura flower. 9. Preparation of cell suspension cultures. 10. Study of cell viability methods. 11. Isolation of protoplast from plant leaves by enzymatic method. 12. Isolation of protoplast from plant leaf by mechanical	 **2 hours** **4 hours** **2 hours** **2 hours** **2 hours** **2 hours** **2 hours** **2 hours** **4 hours** **2 hours** **4 hours** **4 hours**

	method. 13. Study of protoplast viability. 14. Root organ culture (ROC) technique. 15. Preparation of synthetic seeds (alginate beads).	 **2 hours** **4 hours** **2 hours**
Pedagogy:	Laboratory Practicals.	
References/Readings	1. **Aguilar Cristobel Noe** 2008. Food Science and Food Biotechnology in Developing countries. Asiatech Publishers Inc. 2. **Prasad** 2008. Biotechnology in Sustainable Biodiversity and Food Security. India Book House Limited. 3. **Vibha Dhawan** 2008. Biotechnology for Food and Nutritional Security. Teri Press. 4. **Bhojwani, S. S. and Razdan, M. K.** 1997. Plant Tissue Culture: Theory and Practice. Springer Publishers Netherlands. 5. **Rajmohan Joshi** 2006. Agricultural Biotechnology. Gyan Books. 6. **Kumar, H. D.** 2005. Agricultural Biotechnology. Daya Publishing House. 7. **Gautam, H.** 2006. Agricultural & Industrial Applications of Bio-technology. Rajat Publication. 8. **Harikumar, V.** S. 2006. Advances in Agricultural Biotechnology. Regency Publishers. 9. **Bhavneet Kaur, C.P. Malik andChitra Wadhwani** 2008. Current Topics in Biotechnology. M.D. Publications, New Delhi. 10. **Dubey, R. C.** 2009. A text book of Biotechnology. S. Chand & Co. Ltd. New Delhi.	
Learning Outcomes	Able to work in Plant tissue culture laboratory, in Pharmaceutical and ayurvedic drug industries, research laboratories and plant germplasm banks.	

Programme: M. Sc. (Botany)
Course Code: BOO-324
Title of the Course: Mycorrhizal Biotechnology.
Number of Credits: 2
Effective from AY: 2020-21

Prerequisites for the course:	Basic knowledge of Mycology.	
Objective:	To familiarize the students with various aspects of Mycorrhizal fungi, study techniques and their applications.	
Content:	**1. Biofertilizers:** Definition, types, characteristic features, their role and importance in sustainable agriculture. **2. Mycorrhiza**: Definition and historical perspective; Types of mycorrhizae; classification; Phylogeny; general importance. **3. Mycorrhizal Techniques:** Isolation and pure culture preparation of ecto- and endo-mycorrhizae; Criteria for identification - generic and specific level; staining techniques; Trap and pure cultures; *in vitro* culture of AM fungi, commercial production of inoculum. **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. **5. Phosphate transport and role of AM fungi:** Sources of Phosphorus, P uptake from environment; Plant phosphate transporters; Phosphate transport in AM fungi. **(2h)** **6. Phytohormones and AM symbiosis:** Cytokinins, Gibberellins, Ethylene, ABA, Auxins, Salicylic acid, Jasmonic acid; Role of Jasmonates in mycorrhization. **7. Ecology of AM fungi:** Mycorrhiza formation in field soil; effects of N and micronutrients. Microbial interactions, phytoremediation; Effects upon AM fungi – disturbance, agrochemcials and grazing. **8. Production of ectomycorrhizal fungal inocula and inoculation procedures:** Types of ectomycorrhizal inocula; Methods of preparation, inoculums procedures. **9. Arbuscular Mycorrhizae in phytoremediation:**	**2 hours** **2 hours** **3 hours** **4 hours** **3 hours** **2 hours** **3 hours** **3 hours** **2 hours** **4 hours**

	Phytoremediation – definition, advantages and limitations; Contaminated and uncontaminated soils, heavy metals and their effects in plants; Heavy metal detoxification mechanisms in plants and AM fungi; Phytostabilization and phytoextraction; Glomalin and its role; concepts for improving phytoremediation by plant engineering.	
Pedagogy:	Lectures/Assignments/Tutorials/Self study.	
References/Readings	1. **Allan, M. F.** 1991. The Ecology of Mycorrhizae. Cambridge University Press. 2. **Bacon, C. W. and White, J. H.** 2000. Microbial Endophytes Marcel Dekker, New York. 3. **Dwivedi, B. K. and Pandey, G.** 1994. Biotechnology in India. Allahabad: Bioved Research Society. 4. **Read, D. J., Lewis, D. H. Fitter, A. H. and Alexander, I. J.** 1996. Mycorrhizas in Ecosystems. Oxford University Press. 5. **Rodrigues, B. F. and Muthukumar, T.** 2009. Arbuscular Mycorrhizae of Goa – A Manual of Identification Protocols. Goa University, Goa. 135 *pp*. 6. **Schenck, N. C.**1982. Methods and principles of mycorrhizal research. St. Paul Minnesota. 7. **Schenck, N.C. and Perez, Y.** 1990.Manual for the identification of VA mycorrhizal fungi. International Culture Collection of VA Mycorrhizal Fungi. Synergistic Publications, Gainesville, Florida, USA. 8. **Sylvia, D. M., Hung, L. L. and Graham, J. H.** 1987. Mycorrhizae in the next Decade, Practical Applications and Research Priorities. University of Florida. Gainesville, Florida. 9. **Willis, A., B. F. Rodrigues, and Harris, P.J.C.** (2013). The ecology of arbuscular mycorrhizal fungi. Critical Reviews in Plant Sciences 32:1-20.	
Learning Outcomes	Better prospects in agro-based industries.	

Programme: M. Sc. (Botany)
Course Code: BOO-325
Title of the Course: Lab in Mycorrhizal Biotechnology.
Number of Credits: 1 (24 hours)
Effective from AY: 2020-21

Prerequisites for the course:	Basic knowledge of Mycology.	

Objective:	Exercises are designed so that the students will have hands on training in mycorrhizal biotechnology and development.	
Content:	1. Isolation of AM fungal spores from rhizosphere soil. 2. Estimation of AM fungal spore numbers. 3. Techniques of staining roots for AM colonization. 4. Histochemical staining for polyphosphate granules in AM fungal hyphae using Toluidine blue O (TBO). 4. Histochemical staining for lipid bodies in AM fungal hyphae and vesicles using Sudan Black. 5. Preparation of AM fungal inocula: trap and pure cultures. 6. Identification of some commonly occurring AM fungal species based on spore morphology**.** 7. *In vitro* culture of AM fungi.	**2 hours** **4 hours** **4 hours** **2 hours** **2 hours** **6 hours** **6 hours** **4 hours**
Pedagogy:	Laboratory Practicals.	
References/Readings	**1. Allan, M. F.** 1991. The Ecology of Mycorrhizae. Cambridge University Press. **2. Bacon, C. W. and White, J. H.** 2000. Microbial Endophytes Marcel Dekker, New York. **3. Dwivedi, B. K. and Pandey, G.** 1994. Biotechnology in India. Allahabad: Bioved Research Society. **4. Read, D. J., Lewis, D. H. Fitter, A. H. and Alexander, I. J.** 1996. Mycorrhizas in Ecosystems. Oxford University Press. **5. Rodrigues, B. F. and Muthukumar, T.** 2009. Arbuscular Mycorrhizae of Goa – A Manual of Identification Protocols. Goa University, Goa. 135 *pp*. **6. Schenck, N. C.**1982. Methods and principles of mycorrhizal research. St. Paul Minnesota. **7. Schenck, N.C. and Perez, Y.** 1990.Manual for the identification of VA mycorrhizal fungi. International Culture Collection of VA Mycorrhizal Fungi. Synergistic Publications, Gainesville, Florida, USA. **8. Sylvia, D. M., Hung, L. L. and Graham, J. H.** 1987. Mycorrhizae in the next Decade, Practical Applications and Research Priorities. University of Florida. Gainesville, Florida. **9. Willis, A., B. F. Rodrigues, and Harris, P.J.C.** (2013). The ecology of arbuscular mycorrhizal fungi. **Critical Reviews in Plant Sciences** 32:1-20.	
Learning Outcomes	Better prospects in agro-based industries.	

Programme: M. Sc. (Botany)
Course Code: BOO-326
Title of the Course: Plant Histochemistry
Number of Credits: 2
Effective from AY: 2020-21

Prerequisites for the course:	Knowledge of basic Botany at UG level.	
Objective:	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 are 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.	
Content:	**1. Introduction to basic histology:** Cells and tissues and microorganisms. **2. General Techniques:** Chemistry and practice of fixation; whole mounts; sectioning- microtomy, cryo and ultra-microtomy; freeze-drying of biological materials. **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. **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. **5. Polarization microscopy:** Study of structure and components of cell wall, starch, crystals and other anisotropic materials. **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. **7. Electron microscopy:** Specimen preparation for TEM	**1 hour** **2 hours** **8 hours** **3 hours** **1 hour** **3 hours** **1 hour**

	and SEM. **8. Enzyme histochemistry:** Localization of esterases; phosphates and other enzymes. **9. Photomicrography:** Basic techniques of image capturing and image analysis using bight-field, polarization, dark-field and fluorescence microscopy; Conventional and digital photography; basic principles, cameras, lenses, focusing, exposure, resolution, depth of field, lighting, keeping and storing records. **10. Cyto-histochemistry and its applications:** Understanding biological structures of medicinal and other economically important plants; Applications in diagnostic and analytical sciences and biotechnology.	**1 hour** **2 hours** **2 hours**
Pedagogy:	Lectures/ Tutorials/Assignments/Seminars/Self-study.	
References/Readings	1. **Meenakshi Chakraborty.** 2012. Histology & Histochemistry, Wisdom Press, New Delhi. 2. **Shyamasundari, K. and K. Hanumantha Rao.** 2007. Histochemistry in focus. A Source book of techniques and research needs, MJP Publishers, Chennai. 3. **David L. Spector and Robert D. Goldman.** 2006. Basic methods in microscopy, Cold Spring Harbor Laboratory Press, Cold Spring Harbor, New York. 4. **Sharma, V. K.** 1991. Techniques in Microscopy and Cell Biology, Tata McGraw-Hill Publishing Company Limited, New Delhi. 5. **Lacey, A. J.** 1989. Light microscopy in biology a practical approach, IRL Press, Oxford University, UK. 6. **Krishnamurthy, K.V.** 1988. Methods in Plant Histochemistry. S. Viswanthan (Printers & Publishers) Pvt. Ltd., Chennai. 7. **Pears, A.G.E.** 1980. Histochemistry Theoretical and Applied, Preparative and Optical Techniques. Vol. I. Fourth Edition. Churchill Livingstone. London and New York. 8. **Pears, A.G.E.** 1985. Histochemistry Theoretical and Applied. Analytical Technology. Vol. II, Churchill Livingstone. London and New York. 9. **Hayat, M.A.** 1986. Basic Techniques for Transmission Electron Microscopy. Academic Press. London and New York. 10. **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. 11. **Jensen, W.A.** 1962. Botanical Histochemistry	

	Principles and Practice. W. H. Freeman and Company, San Francisco, USA.	
Learning Outcomes	1. Being able to gain insight in fine structure of plant tissues and apply the knowledge of histochemical and microscopic techniques to understand development of various plant species. 2. Being in position to select appropriate stains to differentiate plant tissues in different stages of development. 3. Being able to apply methods and procedures for localization of various compounds, enzymes, minerals etc. 4. Better prospects in pharmacognosy.	

Programme: M. Sc. (Botany)
Course Code: BOO-327
Title of the Course: Lab in Plant Histochemistry.
Number of Credits: 1 (24 hours)
Effective from AY: 2020-21

Prerequisites for the course:	Knowledge of basic Botany at UG level.	
Objective:	To learn and understand various microscopic and histochemical techniques. Localization of various storage compounds such as starch, protein, lipids and other compounds using various fluorescent and non-fluorescent dyes.	
Content:	1. Study of auto-fluorescence in biological specimens using UV, violet, blue and green excitation filters under fluorescence microscopy. 2. Localization of proteins in biological tissues using fluorescent and non-fluorescent dyes. 3. Localization of lipids in biological tissues using fluorescent and non-fluorescent dyes. 4. Study of cell wall structure using the specific fluorochrome like calcofluor white or acridine orange using fluorescence microscopy. 5. Study the distribution of starch in biological specimens using iodine potassium iodide. 6. Study the structure of starch, stomata, crystalline and other anisotropic materials using polarization microscopy. 7. Examination of normal and diseased plant tissues using fluorescence microscopy. 8. Localization of plant cell nuclei using fluorescent and non-fluorescent dyes.	**2 hours** **2 hours** **2 hours** **2 hours** **2 hours** **2 hours** **2 hours** **4 hours**

	9. Localization of minerals such as calcium, potassium and iron in biological tissues. 10. Microphotography using bright-field, dark-field, polarization and fluorescence microscopy. 11. Demonstration of image capture, image analysis, measurement of various parameters of cells and tissues using image analyzing software. 12. Demonstration of scanning electron microscopy.	**6 hours** **2 hours** **2 hours** **2 hours**
Pedagogy:	Hands on Practical.	
References/Readings	1. **Meenakshi Chakraborty.** 2012. Histology & Histochemistry, Wisdom Press, New Delhi. 2. **Shyamasundari, K. and K. Hanumantha Rao.** 2007. Histochemistry in focus. A Source book of techniques and research needs, MJP Publishers, Chennai. 3. **David L. Spector and Robert D. Goldman.** 2006. Basic methods in microscopy, Cold Spring Harbor Laboratory Press, Cold Spring Harbor, New York. 4. **Sharma, V. K.** 1991. Techniques in Microscopy and Cell Biology, Tata McGraw-Hill Publishing Company Limited, New Delhi. 5. **Lacey, A. J.** 1989. Light microscopy in biology a practical approach, IRL Press, Oxford University, UK. 6. **Krishnamurthy, K.V.** 1988. Methods in Plant Histochemistry. S. Viswanthan (Printers & Publishers) Pvt. Ltd., Chennai. 7. **Pears, A.G.E.** 1980. Histochemistry Theoretical and Applied, Preparative and Optical Techniques. Vol. I. Fourth Edition. Churchill Livingstone. London and New York. 8. **Pears, A.G.E.** 1985. Histochemistry Theoretical and Applied. Analytical Technology. Vol. II, Churchill Livingstone. London and New York. 9. **Hayat, M.A.** 1986. Basic Techniques for Transmission Electron Microscopy. Academic Press. London and New York. 10. **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. 11. **Jensen, W.A.** 1962. Botanical Histochemistry Principles and Practice. W. H. Freeman and Company, San Francisco, USA.	
Learning Outcomes	1. Being able to gain insight in fine structure of plant tissues and apply the knowledge of histochemical and microscopic techniques to understand the development	

	of various plant species. 2. Being in position to select appropriate stains to differentiate plant tissues in different stages of development. 3. Being able to apply methods and procedures for localization of various compounds, enzymes, minerals etc. 4. Better prospects in pharmacognosy.	

Programme: M. Sc. (Botany)
Course Code: BOO -328
Title of the Course: Introduction to Paleoflora.
Number of Credits: 1
Effective from AY: 2020-21

Prerequisites for the course:	Should have studied B. Sc. Botany.	
Objective:	To understand evolutionary structuresand processes in Plant groups.	
Content:	Introduction and scope of Paleobotany, Geological eras. Conditions favouring preservations of fossil plants. Classification of fossil plants. Process of fossilization. Non vascular plants- Bacteria, algae, Algal lime-stones, fossilbryophytes and their evolution. Early vascular plants – Psilophytales, Ancient Lycopods, Eqisetales Rhyniales, Sphenophyllales with their evolutionary evidences; fossil ferns foliage, ancient ferns and their evolution. Pteridospermales, Glossopteridales, Ginkgoales, Cordaitales and Coniferales and their evolution. Ancient flowering plants and evolution.	**1 hour** **1 hour** **1 hour** **1 hour** **2 hours** **3hours** **2 hours** **1 hour**
Pedagogy:	Lectures/ Tutorials/Assignments/Self study.	
References/Readings	**Reference Books:** **Arnold CA.** (1947).An introduction to Paleobotany. New York: McGraw Hill Book Company, Inc **Agashe, S. N.**(1995). Paleobotany, Oxford and IBH Publ. Co. Pvt. Ltd, New Delhi. **Banks HP.**(1970) Evolution of plants of the past. Belmont, CA: Wadsworth Publishing Company; Fundamentals of Botany Series. **Kenrick P. Davis P.** (2004) Fossil plants. The Natural History Musuem. London **Taylor T.N, Taylor EL, Krings M.** (2009) Paleobotany:	

	The biology and evolution of fossil plants. 2nd edn: Academic Press Amsterdam.	
Learning Outcomes	1. Being able to understand evolution of plants in geological epochs. 2. Being able to understand importance of fossil plants in conservation.	

Programme: M. Sc. (Botany)
Course Code: BOO-436
Title of the Course: Marine Phytoplanktons
Number of Credits: 1
Effective from AY: 2020-21

Prerequisites for the course:	Should have studied B. Sc. Botany	
Objective:	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	
Content:	Introduction and Ecological Roles **Marine Diatoms:** General characteristics, Life cycle, Morphology and terminology with respect to centric and pennate diatoms **Marine Dinoflagellates:** General characteristics, Morphology and terminology, Microanatomy, Taxonomy and preparation techniques **Planktonic Microflagellates:** General characteristics, Morphology and terminology, Taxonomy of Chromophyta, Cryptophyta and Raphidophyta, Chrysophyta (Dictychophyceae, Prymnesiophyceae-Haptophyceae) Chlorophyta (Euglenophyta, Prasinonohyta and Chlorophtya) **Coccolothophorids:** Holococolithophorids and heterococcolithophorids **Identification, Collection, preservation and preparation techniques**	**3 hours** **3 hours** **4 hours** **2 hours**
Pedagogy:	Lectures/ Tutorials/Assignments/Self-Study	
References/Readings	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.	
Learning outcomes	1. To be able to identify the marine microalgae with a proper knowledge of collection and preparation techniques for different algal groups. 2.To be able to work as consultant/ Assistant in Environmental monitoring Programme	

Programme: M. Sc. (Botany)
Course Code: BOO- 440
Title of the Course: Bioentrepreneurship and Innovation.
Number of Credits: 1
Effective from AY: 2020-21

Prerequisites for the course:	History of scientific ideas, research methodology, biotechnology at UG level.	
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.	
Content:	**1.** Entrepreneurship in the Life Sciences. **2.** Development of Products in the Biomedical Industry. **3.** Integration of science, technology and business. **4.** From Lab to land: scope in agro/food processing industry **5.** Industrial management. **6.** Market analysis. **7.** Business development. **8.** Regulatory mechanisms. **9.** Indian bioentreprenuerial scenario. **10**. Case studies of successful bioentrepreneurs.	**1hour** **1hour** **1hour** **1hour** **1hour** **2hourr** **2hours** **1hour** **1hour** **1hour**
Pedagogy:	Lectures/ Tutorials/Assignments/Seminars/Group Discussion/Expert Lectures/Videos/Mini projects/Moodle based guidance/Self study.	
References/Readings	1. **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. 2. **Byrne John A.** (2011). *World Changers: 25*	

Entrepreneurs Who Changed Business as We Knew it. New York: Penguin.

3. **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.
4. **Judson Bruce** (2004). *Go it alone! The Secret to Building a Successful Business on Your Own*. New York: HarperCollins.
5. **Little Steven S.** (2005). *The 7 Irrefutable Rules of Small Business Growth.* Hoboken: John Wiley & Sons, Inc. 2005.
6. **Lynn Jacquelyn** (2007). *The Entrepreneur's Almanac: Fascinating Figures, Fundamentals and Facts at your Fingertips.* Canada: Entrepreneur Media Inc.
7. **Mohr Angie** (2008). *Finance and Grow Your Own Business.* North Vancouver: International Self-Counsel Press Ltd.
8. **Ramsey David** (2011). *EntreLeadership: 20 Years of Practical Business Wisdom from the Trenches.* New York: Howard Books.
9. **Ries Eric** (2009). *The Lean Startup: How today's Entrepreneurs Use Continuous Innovation to Create Radically Successful Businesses.* New York: Crown Business.
10. **Rogak Lisa** (1999). *Smart Guide to Starting a Small Business.* New York: John Wiley & Sons, Inc.
11. **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.
12. **Strauss Steven D.** (2008). *The Small Business Bible: Everything you need to know to succeed in your small business.* Hoboken: John Wiley & Sons, Inc.
13. **Kathleen Allen** (1995). Launching New Ventures: An Entrepreneurial Approach, Upstart.
14. **Jane Applegate** (1992). Succeeding in Small Business: The 101 Toughest Problems and How to Solve Them, Plume/Penguin.
15. **David H. Bangs, Jr.** (1992). The Start Up Guide: A One-Year Plan for Entrepreneurs, Upstart.
16. **David H. Bangs, Jr.** (1992). The Business Planning Guide: Creating a Plan for Success in

Your Own Business, 6th edition, Upstart.
17. **Gordon B. Baty** (1990). Entrepreneurship for the Nineties, Prentice-Hall.
18. **Roger Bel Air** (1988). How to Borrow Money from a Banker: A Business Owner's Guide, AMACOM.
19. **Thomas P. Bergman** (2002). The Essential Guide to Web Strategy for Entrepreneurs, Prentice Hall PTR.
20. **Amar V. Bhidé** (2000). The Origin and Evolution of New Businesses, Oxford U. Press.
21. **Bruce Blechman and Jay Conrad Levinson** (1991). Guerrilla Financing: Alternative Techniques to Finance Any Small Business, Houghton Mifflin.
22. **Barbara Buchholz, Margaret Crane, and Ross W. Nager** (1999). The Family Business Answer Book: Arthur Andersen Tackles 101 of Your Toughest Questions, Prentice Hall.
23. **Tim Burns Break** (1999). The Curve: The Entrepreneur's Blueprint for Small Business Success, International Thomson Business Press.
24. **Lawrence Finley** (1994). Entrepreneurial Strategies: Text and Cases, PWS-Kent Publishing.
25. **Michael E. Gerber** (1998). The E-Myth Manager: Why Management Doesn't Work—and What to Do About It, HarperBusiness.
26. **David Gladstone** (1988). Venture Capital Handbook, new and revised edition, Prentice-Hall.
27. **Seth Godin** (1998). The Bootstrapper's Bible: How to Start and Build a Business with a Great Idea and Almost No Money, Upstart.
28. **David E. Gumpert** (1990). How to Create a Successful Business Plan, Inc. Publishing.
29. **Craig Hall** (2001). The Responsible Entrepreneur: How to Make Money and Make a Difference, Career Press.
30. **James W. Halloran** (1994). The McGraw-Hill 36-Hour Cour in Entrepreneurship, McGraw-Hill.
31. **Robert D. Hisrich and Michael P. Peters** (1995). Entrepreneurship: Starting, Developing, and Managing a New Enterprise, 3rd edition, Irwin.
32. **Azriela Jaffe** (1998). Let's Go into Business Together: 8Secrets to Successful Business Partnering, Avon Books.

33. **Guy Kawasaki** (1995). How to Drive Your CompetitionCrazy: Creating Disruption for Fun and Profit, Hyperion.
34. **William Lasher** (1994). The Perfect Business Plan- Made Simple, Doubleday Made Simple Books.
35. **James W. Lea** (1991). Keeping It in the Family: Successful Succession of the Family Business, Wiley.
36. **Jay Conrad Levinson** (1997). The Way of the Guerrilla: Achieving Success and Balance as an Entrepreneur in the 21st Century, Houghton Mifflin.
37. **Jay Conrad Levinson** (1984). Guerrilla Marketing: Secrets for Making Big Profits from Your Small Business, Houghton Mifflin.
38. **Charles P. Lickson** (1994). A Legal Guide for Small Business: How to Do It Right the First Time, Crisp Publications.
39. **Gary S. Lynn and Norman M. Lynn** (1992). Innopreneurship: Turning Bright Ideas into Breakthrough Business for Your Company, Probus Publishing.
40. **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.
41. **Bill Meyer** (1998). Cash Flow: A Practical Guide for the Entrepreneur, Perc Press.
42. **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.
43. **Russell Robb** (1995). Buying Your Own Business, Adams Media Corp.
44. **Robert Ronstadt** (1988). Entrepreneurial Finance: Taking Control of Your Financial Decision Making, Lord Publishing.
45. **Eric S. Siegel, Brian R. Ford, and Jay M. Borstei** (1993). The Ernst & Young Business Plan Guide, 2nd edition, Wiley.
46. **David Silver** (1993). Cashing Out: How to Value and Sell Privately Held Company, Enterprise Dearborn.
47. D**avid Silver** (1989). Business Bible for Survival:

	What to Do When Your Company Falls on Hard Times, Prima. 48. **Lawrence W. Tuller** (1997). Finance for Non-Financial Managers and Small Business Owners, Adams Media Corporation. 49.**Karl H. Vesper** (1990). New Venture Strategies,revised edition, Prentice Hall. 50. **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. 51. **Anthony Scott D.** (2012). The Little Black Book of Innovation: How It Works, How to Do It. Boston: Harvard Business Review Press, 281pp. 52.**Berkun Scott** (2010). The Myths of Innovation.Sebastopol, CA: O Reilly Media, 225pp. 53. **Napier Nancy K. and Mikael Nilsson** (2008). The Creative Discipline: Mastering the Art and Scienceof Innovation Westport: Praeger, 227pp.	
Learning Outcomes	1. To be able to prepare a business plan and launch career as bioentrepreneur. 2. Being able to get employment in a bioindustry or a bioconsultancy.	

Programme: M. Sc. (Botany)
Course Code: BOO-441
Title of the Course: Lab in Bioentrepreneurship and Innovation.
Number of Credits: 1 (24 hrs)
Effective from AY: 2020-21

Prerequisites for the course:	Basic knowledge of biology and biotechnology, biotech based industries and brands, IPR issues	
Objective:	To train students for bioentrepreneurship based self employment	
Content:	Students would be given short orientation and assigned / placed in a typical bioindustry and would work under guidance of the nominee of the company for duration at the work place equivalent to 12 hours to produce a report in prescribed format. The report needs to be submitted before end of the semester. 1. Internship orientation case studies 2. Shop floor briefing at company	 **2 hours** **2 hours**

	3. Company assigned internship at the site 4. Weekly Report preparation 5. Terminal report preparation	**15 hours** **2 hours** **3 hours**
Pedagogy:	Lectures/Videos/Interviews/Industrial apprenticeship	
References/Readings	1. **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. 2. **Byrne John A.** (2011). *World Changers: 25 Entrepreneurs Who Changed Business as We Knew it.* New York: Penguin. 3. **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. 4. **Judson Bruce** (2004). *Go it alone! The Secret to Building a Successful Business on Your Own*. New York: HarperCollins. 5. **Little Steven S.** (2005). *The 7 Irrefutable Rules of Small Business Growth.* Hoboken: John Wiley & Sons, Inc. 2005. 6. **Lynn Jacquelyn** (2007). *The Entrepreneur's Almanac: Fascinating Figures, Fundamentals and Facts at your Fingertips.* Canada: Entrepreneur Media Inc. 7. **Mohr Angie** (2008). *Finance and Grow Your Own Business.* North Vancouver: International Self-Counsel Press Ltd. 8. **Ramsey David** (2011). *EntreLeadership: 20 Years of Practical Business Wisdom from the Trenches.* New York: Howard Books. 9. **Ries Eric** (2009). *The Lean Startup: How today's Entrepreneurs Use Continuous Innovation to Create Radically Successful Businesses.* New York: Crown Business. 10. **Rogak Lisa** (1999). *Smart Guide to Starting a Small Business.* New York: John Wiley & Sons, Inc. 11. **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. 12. **Strauss Steven D.** (2008). *The Small Business Bible: Everything you need to know to succeed in your small business.* Hoboken: John Wiley & Sons, Inc.	

13. **Kathleen Allen** (1995). Launching New Ventures: An Entrepreneurial Approach, Upstart.
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19. **Thomas P. Bergman** (2002). The Essential Guide to Web Strategy for Entrepreneurs, Prentice Hall PTR.
20. **Amar V. Bhidé** (2000). The Origin and Evolution of New Businesses, Oxford U. Press.
21. **Bruce Blechman and Jay Conrad Levinson** (1991). Guerrilla Financing: Alternative Techniques to Finance Any Small Business, Houghton Mifflin.
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25. **Michael E. Gerber** (1998). The E-Myth Manager: Why Management Doesn't Work—and What to Do About It, HarperBusiness.
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37**. Jay Conrad Levinson** (1984). Guerrilla Marketing: Secrets for Making Big Profits from Your Small Business, Houghton Mifflin.
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39. **Gary S. Lynn and Norman M. Lynn** (1992). Innopreneurship: Turning Bright Ideas into Breakthrough Business for Your Company, Probus Publishing.
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43. **Russell Robb** (1995). Buying Your Own Business, Adams Media Corp.
44. **Robert Ronstadt** (1988). Entrepreneurial Finance: Taking Control of Your Financial Decision Making, Lord Publishing.
45**. Eric S. Siegel, Brian R. Ford, and Jay M.**

	Borstei (1993). The Ernst & Young Business Plan Guide, 2nd edition, Wiley. 46. **David Silver** (1993). Cashing Out: How to Value and Sell Privately Held Company, Enterprise Dearborn. 47. D**avid Silver** (1989). Business Bible for Survival: What to Do When Your Company Falls on Hard Times, Prima. 48**. Lawrence W. Tuller** (1997). Finance for Non-Financial Managers and Small Business Owners, Adams Media Corporation. 49**. Karl H. Vesper** (1990). New Venture Strategies, revised edition, Prentice Hall. 50**. 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. 51. **Anthony Scott D.** (2012). The Little Black Book of Innovation: How It Works, How to Do It. Boston: Harvard Business Review Press, 281pp. 52. **Berkun Scott** (2010). The Myths of Innovation.Sebastopol, CA: O Reilly Media, 225pp. 53. **Napier Nancy K. and Mikael Nilsson** (2008). The Creative Discipline: Mastering the Art and Science of Innovation Westport: Praeger, 227pp.	
Learning Outcomes	1. Being able to launch career as bioentrepreneur. 2. Being able to work as a consultant for bioindustries. 3. Being able to find employment in a biobased production or marketing industry. 4. Being able to do biomarket analysis and prepare a biobusiness plan.	

Programme: M. Sc. (Botany)
Course Code: BOO- 442
Title of the Course: Mushroom Biotechnology.
Number of Credits: 1
Effective from AY: 2020-21

Prerequisites for the course:	Knowledge of mushrooms at UG level.	
Objective:	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.	
Content:	**1.** Edible and medicinal mushrooms, criteria for edibility, domestication of edible and medicinal mushrooms. **2.** Mushroom biotechnology principles- as applied to commercial species (top six). **3.** Spawn development and quality parameters, **4.** Production and quality management. **5.** Harvesting, grading, branding, marketing. **6.** Mushrooms-post harvest processing and value addition. **7.** Mushroom marketing, scope for new species, scope in tropical countries. **8.** Future of mushroom industry-global, national, local perspectives.	1hour 2hours 1hour 2hours 2hours 1hour 2hours 1hour
Pedagogy:	Lectures/ Tutorials/Assignments/Seminars/Videos/Moodle based guidance/Expert Lectures/Self study.	
References/Readings	1. **Arora, D.** (1986). Mushrooms demystified: A comprehensive guide to the fleshy fungi. Berkeley: Ten Speed Press. 959 pp. 2. **Kuo, M.** (2007). 100 Edible Mushrooms. Ann Arbor: University of Michigan Press. 329 pp. 3. **Kuo, M. and A. Methven** (2010). 100 Cool Mushrooms. Ann Arbor: University of Michigan Press. 210 pp. 4. **Largent, D. L.** (1973). How to identify mushrooms to genus I: Macroscopic features. Eureka, CA: Mad River Press. 86 pp. 5. **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. 6. **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. 7. **Largent, D. L. and Baroni, T. J.** (1988). How to identify mushrooms to genus VI: Modern genera. Eureka, CA: Mad River Press. 277 pp. 8. **Lockwood, T. F.** (2002). Treasures from the kingdom of fungi. Korea: Taylor Lockwood. 127 pp. 9. **McKnight, K. H. and McKnight, V. B.** (1987). Mushrooms (Peterson Field Guides). New York: Houghton Mifflin. 429 pp. 10. **Money, N. P.** (2002). Mr. Bloomfield's orchard: The mysterious world of mushrooms, molds, and	

mycologists. New York: Oxford UP. 208 pp.
11. **Money, N. P.** (2005). Why picking wild mushrooms may be bad behaviour. Mycological Research 109: 131-135.
12. **Moser, M.** (1983). Keys to Agarics and Boleti (Polyporales, Boletales, Agaricales, Russulales). Ed. Kibby, G. Transl. Plant, S. London: Roger Phillips. 535 pp.
13. **Pacific Northwest Key Council** (2006). Keys to mushrooms of the Pacific Northwest. Retrieved from the Pacific Northwest Key Council.
14. **Phillips, R.** (1981). Mushrooms and other fungi of Great Britain & Europe. London: Pan Books.
15. **Phillips, R.** (1991). Mushrooms of North America. Boston: Little, Brown and Company. 319 pp.
16. **Roody, W. C.** (2003). Mushrooms of West Virginia and the central Appalachians. Korea: U Kentucky P. 520 pp.
17. **Rumack, Barry H., and David G. Spoerke** (1994). *Handbook of mushroom poisoning: diagnosis and treatment*. CRC Press, 1994.
18. **Smith, A. H.** (1949). Mushrooms in their natural habitat. New York: Hafner Press. 626 pp.
19. **Smith, A. H.** (1975). The mushroom hunter's field guide. Ann Arbor: U Michigan P. 264 pp.
20. **Smith, A. H., Smith, H. V. and Weber, N. S.** (1979). How to know the gilled mushrooms. Dubuque, Iowa: Wm. C. Brown. 334 pp.
21. **Smith, A. H., Smith, H. V. and Weber, N. S.** (1981). How to know the non-gilled mushrooms. Dubuque, Iowa: Wm. C. Brown. 324 pp.
22. **Oei, Peter.** (1996). Mushroom cultivation: with special emphasis on appropriate techniques for developing countries. Leiden: Tool Publications.
23. **Chang, S.T. and W. A. Hayes** (2013). The Biology and Cultivation of Edible Mushrooms. Academic Press Inc., New York, New York. 819 pp.
24. **Ontario Mushroom Pesticide Recommendations**. Publication 367. Information Branch, Ontario Ministry of Agriculture and Food, Parliament Buildings, Toronto, Ontario.
25. **Penn State Handbook for Commercial Mushroom Growers**. Penn State University. University Park, Pennsylvania, U.S.A. 16802. 130 pp.

26. **Rinker, D.L.** Commercial Mushroom Production. Ontario Ministry of Agriculture and Food, Parliament Buildings, Toronto, Ontario.
27. **Stamets, P. and J., S. Chilton** (1983). The Mushroom Cultivator. Agarikon Press, Olympia, Washington.
28. **Vedder, P.J.C.** (1978). Modern Mushroom Growing. Grower Books. 50 Doughty Street, London, England WCIN 2LP. 420 pp.
29. **Ram Dutta, Satish** (2007). Advances in Mushroom Science: Serial Pub, 2007, 240 p,
30. **T. N. Lakhanpal, Onkar Shad and Monika Rana** (2010). I. K. Biology of Indian Morels: International, 2010, 266 pp.
31. **V. P. Sharma and B. C. Suman** (2006). Diseases and Pests of Mushrooms: Agrobios, xiv, 212 pp.
32. **S. Kannaiyan, T. Marimuthu and K. Lenin** (Ed), Diversity and Production of Edible Mushrooms: Associated Publishing Company, 2011, 184 pp.
33. **Engineers India Research Institute**, (2006). Hand Book of Mushroom Cultivation, Processing and Packaging, 256 pp.
34. **Anonymous** (2006). Handbook on Mushroom Cultivation and Processing: With Dehydration, Preservation and Canning: Asia Pacific Business Press, 522 pp.
35. **Reeti Singh and U.C. Singh** (2011). Modern Mushroom Cultivation: Agrobios, 229.
36. **B.C. Suman and V.P. Sharma** (2005). Mushroom: Cultivation, Processing and Uses:, Agrobios, 349 pp.
37. **J. K. Singh** (2012). Mushroom: Diseases and Its Control: Enkay Pub, 264 pp.
38. **Nilanjana Das** (2008). Mushroom: Its Wild Relatives: Researchco Book Centre, 174 pp.
39. **S.K. Singh and P.K. Jha** (2014). Mushroom: Production and Utilization: Scientific Publishers, 2014, 189 pp.
40. **J. K. Singh** (2011). U.K. Prasad and Anshu Priyadarshini, Mushroom: The Future Vegetable: Cultivation, Processing and Marketing Enkay Publishing House, 270 pp.
41. **B. C. Suman and V. P. Sharma**, (2014). Mushroom Cultivation in India: Daya, Reprint, 180 pp.

	42. **Robin Gogoi, Yella Rathaiah and Tasvina Rahman Borah** (2006). Mushroom Cultivation Technology: Scientific, 130 pp. 43. **B. L. Jana** (2014). Mushroom Culture: Agrotech Publishing Academy, 152 pp. 44. **S. C. Dey** (2004). Mushroom Growing: Agrobios, 92 pp. 45. **V.N. Pathak, Nagendra Yadav and Maneesha Gaur** (2011). Mushroom Production and Processing Technology: Agrobios, 180 pp. 46. **M. N. Jha and Dayaram** (2004). Mushrooming of Mushroom: Today and Tomorrow's printers, 2004, 132 pp. 47. **S.Biswas, M. Datta, S. V. Ngachan** (2007). Mushrooms: A Manual For Cultivation: PHI Learning, 220 pp. 48. **R. C. Ram Aavishkar** (2007). Mushrooms and Their Cultivation Techniques. 164 pp. 49. **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.	
Learning Outcomes	1. Being able to appreciate the ethnomycological traditions and role of edible mushrooms in culture and economy. 2. Being able to analyse mushroom production and marketing trends. 3. Being able to work in a mushroom industry.	

Programme: M. Sc. (Botany)
Course Code: BOO- 443
Title of the Course: Lab in Mushroom Biotechnology
Number of Credits: 1(24 hours)
Effective from AY: 2020-21

Prerequisites for the course:	Basic knowledge of mycology, ethnomycology, microbiological techniques	
Objective:	To train students in various aspects of production, quality evaluation and marketing of edible mushrooms and their nutritional importance	
Content:	1.Identification of mushroom habitats. 2. Identification of edible, medicinal and toxic mushroom species. 3. Obtaining and studying mushroom spore prints.	**2 hours** **2 hours**

	4. Developmental biology of local wild mushrooms. 5. Preparation of pure mushroom cultures. 6. Production of SCP from submerged culture of edible mushrooms. 7. Production and evaluation of mushroom spawn. 8. Oyster mushroom cultivation using tissue paper rolls 9. Mushroom quality evaluation- button or oyster mushrooms. 10. Report on Button mushroom industry after field visit.	**1 hour** **2 hours** **2 hours** **4 hours** **4 hours** **4 hours** **2 hours** **1 hour**
Pedagogy:	Practical Exercizes, Mini Projects, Hands on demos, Videos, Moodle based guidance.	
References/Readings	**1.Arora, D.** (1986). Mushrooms demystified: A comprehensive guide to the fleshy fungi. Berkeley: Ten Speed Press. 959 pp. **2.Kuo, M.** (2007). 100 Edible Mushrooms. Ann Arbor: University of Michigan Press. 329 pp. **3.Kuo, M. and A. Methven** (2010). 100 Cool Mushrooms. Ann Arbor: University of Michigan Press. 210 pp. **4.Largent, D. L.** (1973). How to identify mushrooms to genus I: Macroscopic features. Eureka, CA: Mad River Press. 86 pp. **5.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.	
Learning Outcomes	1. Ability to cultivate edible mushrooms. 2. Ability to produce quality mushroom spawn. 3. Better prospects to work in a mushroom farm or factory. 4. Ability to produce consultancy reports on mushroom marketing and production. 5. Ability to launch value added mushroom processing enterprises. 6. Ability to promote edible mushrooms as nutraceuticals. 7. Ability towork as mster trainer in mushroom. cultivation camps or workshops for women, SC, ST.	

Course Code: BOO- 447
Title of the Course: Ecotourism.
Number of Credits: 2
Effective from AY: 2020-21

Prerequisites for the course:	General idea of tourism. Flora and fauna of western ghats of Goa, history and culture of India.	
Objective:	Supported by local tourism industry this need based course is 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.	
Content:	**1. Eco-tourism:** Definition, concept, introduction, history, relevance and scope. **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. **3. Components of Ecotourism:**Travel, tourism industry, biodiversity, local people, cultural diversity, resources, environmental awareness, interpretation, stake holders, capacity building in ecotourism. **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. **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, rural handicrafts, tribal medicines, archeological sites, adventure sports, sacred groves, mountains, etc. **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.	**1hour** **1hour** **2hours** **4hours** **7hours** **4hours**

	Community based ecotourism, ecotourism and NGOs. **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. **8. Ecotourism and livelihood security:** Community, biodiversity conservation and development – Eco-development committees.	**3hours** **2hours**
Pedagogy:	Lectures/ Tutorials/Videos/Films/Group Discussion/Expert Lectures/Assignments/Self-Study	
References/Readings	**1.A K Bhattacharya**. 2005. Ecotourism and Livelihoods. Concept Publ. Company, New Delhi. **2.Kreg Lindberg, Deonal E. Hawkins.** 1999. Ecotourism: A guide for Planners and Managers. Natraj Publishers, Dehradun. **3.Batta, A.** 2000. Tourism and environment. Indus Publishing Co., New Delhi. **4.Cater, E.** 1994. Ecotourism in the third world: Problems and prospects for sustainability. **5.Cater and G. Lowman** Ecotourism: a sustainable option, Wiley, Chichester. **6.Croall, J.** 1995. Preserve or Destroy: Tourism and Environment, CalousteGulbenkian Foundation, London.	
Learning Outcomes	1. Being able to work in an ecotourism industry. 2. Being able to work as an ecotourism guide or tour operator. 3. Being ble to work as an ecotourism planner or consultant. 4. Being able toproduce documentaries and movies on ecotourism.	

Programme: M. Sc. (Botany)
Course Code: BOO- 448
Title of the Course: Lab in Ecotourism.
Number of Credits: 2 (24 hours sessions, one credit 12 hours of apprenticeship)
Effective from AY: 2020-21

Prerequisites for the course:	General idea of tourism industry, local flora, fauna, cultural and natural heritage	
Objective:	To impart training in ecotourism based goods and services	

	for purpose of creating trained manpower for ecotourism projects in Goa in particular and western ghats in general and give students practical experience in ecotourism industry as short term apprentices	
Content:	1. Ecotourism websites, portals and documentaries. 2. Ecotourism films appreciation. 3. Production of ecotourism photo portfolio. 4. Production and display of thematic original videofilm of short duration. 5. Production of a thematic ecotourism blog or website. 6. Designing of an artistic publicity brochure or poster on Ecotourism. 7. Submission of a short new ecotourism project proposal in standard format **Internship** 1. Pre Internship work – 2. Internship at assigned ecotourism facility 3. Preparation of terminal report	**2 hours** **2hours** **2 hours** **1 hour** **2 hours** **2 hours** **1 hour** **1 hour** **10hours** **1 hour**
Pedagogy:	Mini Projects, Hands on exercises, Demos, Portal and Blog Design, Photographic and Videographic sessions, Field visits, Experts lectures, Videos, Apprenticeship at Ecotourism Facility.	
References/Readings	**1.A K Bhattacharya**. 2005. Ecotourism and Livelihoods. Concept Publ. Company, New Delhi. **2.Kreg Lindberg, Deonal E. Hawkins.** 1999. Ecotourism: A guide for Planners and Managers. Natraj Publishers, Dehradun. **3.Batta, A.** 2000. Tourism and environment. Indus Publishing Co., New Delhi. **4.Cater, E.** 1994. Ecotourism in the third world: Problems and prospects for sustainability. **5.Cater and G. Lowman** (Ed.). Ecotourism: a sustainable option, Wiley, Chichester. **6.Croall, J.** 1995. Preserve or Destroy: Tourism and Environment, CalousteGulbenkian Foundation, London.	
Learning Outcomes	1.Being able to find jobs in an ecotourism industry. 2. Launch one's own ecotourism project. 3. Have confidence to work as an ecotourism guide. 4. Have ability to prepare market survey reports or consultancy reports on ecotourism. 5. Have ability to contribute to framing of	

	ecotourism policies and strategies. 6. Better prospects to work as travel writer, food columnist etc. 7. Better capacity to produce documentaries and photographs on ecotourism destinations.	

Programme: M. Sc. (Botany)
Course Code: BOO-449
Title of the Course: Advanced Ecology.
Number of Credits: 3
Effective from AY: 2020-21

Prerequisites for the course:	Knowledge of environment, environmental issues, earth Fsystem processes, weather parameters, geography and basic ecology and biodiversity at U.G. Level.	
Objective:	This course specially catered to needs of students in a world facing challenges of global warming 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 with special emphasis on tropical environment, western ghats, Arabian sea and issues like urbanization and sustainable development.	
Content:	**1. Ecology of climate change and development (ECCD):** Climate change-the current picture after COP-21; Importance of findings of AR-5 of IPCC; 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. **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, , fungicides and herbicides used in gardening, agriculture and forestry, advantages – disadvantages with biological control	**5hours** **4hours**

	methods; tropical case studies-social insects such as dampwood and mound building termites. **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. **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, Landscape restoration, Landscape management: Natural variability, scientific uncertainty, and sustainability; Case studies from India-habitat fragmentation in western ghats, in mining areas etc. **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; Smart cities in India, , What is Industrial Ecology?, Environmental Paradigm, Sustainability: Concepts and Metrics, Materials flow and Life cycle assessment (LCA), industrial ecosystems, case studies e.g. Kalundberg, Thane. **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	**3hours** **7hours** 6hrs **6hours**

	performance of a company or organisation, with appropriate case studies; Importance of EE in national planning and development. **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.	**5hours**
Pedagogy:	Lectures/Tutorials/Assignments/Seminars/Self-study/Videos/Moodle/Expert Lectures/Group Discussion/Mini Projects/Workshops	
References/Readings	1. **Christianson G. E.** (2000). Green House, The 200 year story of Global warming, Universities Press, India. 2. **Modak Prasad and Biswas asit K.** (1999). Conducting environmental impact assessment in developing countries, OUP. 3. **Kadekodi Gopal K.** (2004). Environmental economics in practice, Oxford University Press (OUP). 4. **Lemont C. Hempel.** (1998). Environmental governance-the global challenge, AEW Press. 5. **Herma Vehoef and Peter J. Morin.** (2010). Community ecology, Processes, models and applications, 2nd edition, OUP. 6. **Mark J. McDonnell, Amy K. Hahs and Jürgen H. Breuste.** (2009). Ecology of Cities and Towns: A Comparative Approach, Cambridge University Press. 7. **Marcel Dicke and William Takken** (2006). Chemical ecology: From genes to ecosystems, Springer. 8. **Thomas Eisner and Jerrold Meinwald** (2004). Chemical Ecology: The Chemistry of Biotic Interaction National Academy of Sciences. 9. **Dietland Müller-Schwarze.** (2009). Hands-On Chemical Ecology: Simple Field and Laboratory Exercises. 10. **Inderjit and Azim U. Mallik.** (2003). Chemical Ecology of Plants, Academic Press.	
Learning Outcomes	1. Gain a better knowledge of global, national and local environmental issues. 2. Get the ability to take an informed position on	

	environmental issues. 3. Be able to contribute to Smarts City and urban forestry projects. 4. Better understanding of Environmental impacts of projects.	

Programme: M. Sc. (Botany)
Course Code: BOO - 450
Title of the Course: Lab in Advanced Ecology.
Number of Credits: 1 (Total sessions 24 hours)
Effective from AY: 2020-21

Prerequisites for the course:	Basic knowledge of field work, sampling theory, on line weather monitoring, chemical and microbiological analysis, use of maps and charts, software tools, ecoinformatics, Google Earth.	
Objective:	To impart knowledge of field , lab and IT based ecological techniques in a world affected by global warming and climate change and to equip students to independently analyze any environmental issue and where possible think of appropriate solutions in a studious manner.	
Content:	**1.** Analysis of IPCC data on climate change. **2.** Analysis of ICE core data for temperature and carbon di-oxide levels. **3.** Analysis of Mauna Kea data for Carbon dioxide levels. **4**.Using online weather monitoring systems and generating reports-sea level gauges. **5.** Study of proxies for sea level fluctuations- marine fossils. **6.** Sampling and analysis of rainwater for physicochemical and biological/microbiologicalconstituents. **7**. Detection of chemical trails of ants and termites. **8.** Responses of ants and termites to different chemicals. **9.** Field observations on termite hill and fungus combs. **10.**Analysis of vermicasts for organic matter, micronutrients. **11.** Study of ecotones and edges in natural ecosystems. **12**. Application of quadrat studies in landscape science. **13.** Analysis of soil humic matter. **14.** Detection of soil enzymes using chromogenic substrates. **15.** Isolation of soil microbiota and assessment of their ecological role. **16.** Landscape analysis and modeling using software tools. **17.** Study of local landscapes using maps and satellite images.	**Total 12 sessions, All sessions of 2 hours each, any 3 from 1-6; any 2 from 6 to 10; any 2 from 11 to 15; any 2 from 16 to 22 and any 3 from 23 to 30**

	18. Landscape analysis using satellite imagery data using Google Earth *etc*. **19.** Study of land use change -urbanization, mining, tourism using Google Earth. **20.** Cataloguing urban land use and biodiversity using maps and field data. **21.**Conceptualizing a model urban ecosystem using design tools. **22.** Flowcharting/drawing an industrial ecosystem. **23.**Evaluating local ecosystem services using standard equations (Costanza, 1997). **24.** Conceptualizing rainwater harvesting system for an industrial estate. **25.** Performing Rapid EIA using Leopold interaction matrix (different projects). **26.** Study of technical reports on Solid Waste Management. **27.** Software for EIA –solid waste management. **28**. Performing rapid biological impact analysis. **29.**Preparation of Infographics on different ecological themes. **30.** Production of a brochure on given ecological themes.	
Pedagogy:	Lectures/ Tutorials/Assignments/ Mini Projects/Use of software tools and online websites/Moodle based Exercizes/ Videos/ Demonstrations/ Field visits/Self-study/Expert Lectures/Training workshops.	
References/Readings	**Dietland Müller-Schwarze**(2009). Hands-On Chemical Ecology: Simple Field and Laboratory Exercises.	
Learning Outcomes	1. To be able to use IPCC data on global warming. 2. To be able to use IT based platforms for monitoring weather and sea level changes. 3. Ability to work as a tropical field ecologist. 4. Use Google Earth effectively for various purposes. 5. Be able to independently work as EIA consultant or urban forestry consultant. 6. Be able to participate in Smarts city projects planning and execution. 7. To begin career as ecological consultant. 8. Better scope as environmental journalist. 9. Better scope to work for environmental NGOs.	

Programme: M. Sc. (Botany)
Course Code: BOO-451
Title of the course: Plant Biochemistry
Number of Credits: 3
Effective from AY: 2020-2021

Prerequisites for the course:	Students should have studied B. Sc. Botany with a basic knowledge of plant physiology and biochemistry at the UG level.	
Objective:	This paper provides the deeper understanding of isomerism of biomolecules, biomembranes, bioenergetics and regulation of metabolic pathways in plants. Students will also learn mechanism of enzyme action with introduction to cellular and molecular mechanism of signal transduction.	
Content:	1. **Biomolecules:** Structure, function and isomerism: Organization and composition of eukaryotic cells; integration and control of cellular functions; amino acid composition of proteins; higher levels of protein organization; dynamic aspects of protein structure and protein stability. Plant biopolymers: Cellulose, hemicellulose, xylan and pectin. Biominerals in plant such as phytoliths and calcium oxalate. 2. **Mechanism of enzyme action:** Introduction to enzymes; Michaelis-Menten model; enzyme kinetics as an approach to understanding mechanism; enzymatic reactions; regulatory enzymes; reversible and irreversible covalent modifications of enzymes. 3. **Metabolic pathways and regulation:** Major metabolic pathways and their regulation; biosynthesis of amino acids; purine and pyrimidine metabolism; metabolic interrelationships; biosynthesis of vitamins. 4. **Biomembranes and Bioenergetics:** Physico-chemical properties of biological membranes; their distribution and organization; intrinsic and extrinsic proteins; transport of biomolecules across membrane; passive and active transport; role of membrane in cellular metabolism. Bioenergetics: Thermodynamics; exergonic and endergonic reactions; redox potential; high energy compounds; ATP structure and its significance. 5. **Expression and signal transduction:** Gene expression in eukaryotes; genetic control of enzyme synthesis; cell surface receptors; G proteins coupled secondary messenger and response to	**10 hours** **6 hours** **8 hours** **8 hours** **4 hours**

	environmental changes and other stimuli.	
Pedagogy:	Lecture through PPT/e-learning/Assignments/Seminars/Self study	
References/Readings	1. **Berg, Jeremy M** (2012) Biochemistry. WH Freeman and Company, New York. 2. **Bowsher C** (2008) Plant Biochemistry. Garland Science, New York. 3. **Brown TA** (2018) Biochemistry. Viva Books Pvt. Ltd., New Delhi. 4. **Buchanan, Bob B** (2000) Biochemistry and Molecular Biology of plants. Maryland American Society. 5. **Buchanan, Bob B** (2007) Biochemistry and Molecular Biology of Plants. I K International Pvt. Ltd., New Delhi. 6. **Campbell** D (1999) Biochemistry. Saunders College Publishing, Philadelphia. 7. **Cooper GM** (2000) The Cell: A Molecular Approach. Sinauer Associates, Sunderland (MA). 8. **Davies D** (1980) The Biochemistry of Plants. Academic Press, USA. 9. **Devlin TM** (2011) Textbook of Biochemistry with Clinical Correlations. John Wiley and Sons, Inc., New York. 10. **Donald V and Judith GV** (2011) Biochemistry. John Wiley and Sons Asia Pvt. Ltd., New Jersey. 11. **Garret RH and Grisham CM** (2010) Biochemistry. Cengage Learning, Boston. *12.* **Hames D** (2005) Biochemistry. Taylor and Francis, New Delhi. 13. **Heldt, Hans-Walter** (2005) Plant Biochemistry. Reed Elsevier India Pvt. Ltd., New Delhi. 14. **Heldt, Hans-Walter** (2011) Plant Biochemistry. Academic Press, Amsterdam, USA. 15. **Jones R** (2000) Biochemistry and Molecular Biology of Plants, American Society of Plant Physiologists, USA. 16. **Lehninger AL** (2013) Principles of Biochemistry. WH Freeman and Company, New York. 17. **Lodish H, Berk A, Kaiser CA, Krieger M, Bretscher A, Ploegh H, Amon A and Scott MP** (2013) Molecular Cell Biology. WH Freeman and Company, New York. 18. **Lubert S** (2002) Biochemistry. WH Freeman and Company, New York. 19. **Metzler P, David E** (2006) Biochemistry. Elsevier India Pvt. Ltd., New Delhi. 20. **Mishra SR** (2010) Plant Biochemistry. Discovery Publishing House Pvt. Ltd., New Delhi. 21. **Mishra SR** (2011) Understanding Plant Biochemistry.	

	Discovery Publishing House Pvt. Ltd., New Delhi. 22. **Nelson DL, Cox MM and Lehninger AL** (2013) Principles of Biochemistry. Freeman, New York. 23. **Nicholas CP and Lewis S** (1999) Fundamentals of Enzymology. Oxford University Press Inc., New York. 24. **Ochs, Raymond S** (2014) Biochemistry. Jones and Bartlett Learning, Burlington. 25. **Sheehan D** (2009) Physical Biochemistry. Wiley-Blackwell, West Sussex. 26. **Sheehan M** (1994) Biochemistry and Molecular Biology. Thomas Nelson and Sons, United Kingdom. 27. **Singh SK** (2009) Plant Physiology and Biochemistry. Campus Books International, New Delhi. 28. **Voet DJ, Voet JG and Pratt** CW (2008) Principles of Biochemistry. John Wiley and Sons, Inc., New York. 29. **Voet DJ** (1995) Biochemistry. John Wiley and Sons, New York.	
Learning Outcomes:	Students will be able to demonstrate a depth of knowledge of biochemical processes together with a better understanding of interaction and regulation of various metabolic pathways.	

Programme: M. Sc. (Botany)
Course Code: BOO-452
Title of the course: Lab in Plant Biochemistry
Number of Credits: 1
Effective from AY: 2020-2021

Prerequisites for the course:	Knowledge of the subject at UG level to be able to prepare various types of solutions, and handle basic laboratory tools and techniques.	
Objective:	This course is designed primarily to relate the learning of concepts in classroom to demonstrate experimental foundation of underline concepts/principles mainly on aspects of biomolecules, its metabolic processes and enzymes.	

Content:	1. Extraction and estimation of proteins from plants. (2P) 2. Extraction and estimation of amino acids from plants. (2P) 3. Extraction and estimation of total sugar and reducing sugars from plant samples. (2P) 4. Separation of protein by PAGE (preparation of gel, preparation of protein sample, running, development and documentation of gel). (3P) 5. Extraction and purification of lipids from leaf samples. (1P) 6. Separation of glycolipids, phospholipids and neutral lipids (chromatographically). (3P) 7. Quantitative estimation of phospholipids and glycolipids (spectrophotometrically). (2P) 8. Activity of enzyme phosphoenol pyruvate carboxylase (PEPC). (1P) (Note: Any 10 practical exercises will be conducted.)	4 hours 4 hours 4 hours 6 hours 2 hours 6 hours 4 hours 2 hours
Pedagogy:	Wet laboratory exercises	
References/Readings:	1. **Bhainagar R** (1987) Manual of Practical Biochemistry. Delhi IBT Publishing, New Delhi. 2. **Boyer R** (2000) Modern Experimental Biochemistry. Delhi Pearson Education, New Delhi. 3. **Cooper TG** (2011) The Tools of Biochemistry. Wiley India Pvt. Ltd., New Delhi. 4. **Devi P** (2005) Principles and Methods of Plant Molecualr Biology, Biochemistry and Genetics. Jodhpur Agrobios, Jodhpur. 5. **Harborne JB** (2007) Phytochemical Methods. Chapmann and Hall, London. 6. **Harisha S** (2006) Biotechnology Procedures and Experiments Handbook. Firewall Media, New Delhi. 7. **Jayaraman J** (2011) Laboratory Manual in Biochemistry. John Wiley and Sons Ltd. 8. **Palmer T and Bonner** T (2003) Enzymes: Biochemistry, Biotechnology, Clinical Chemistry. Woodhead Publishing House, Chichester, England. 9. **Plummer DT** (2014) An Introduction to Practical Biochemistry. Tata McGraw Hill publishing company Ltd., New Delhi. 10. **Sadasivam S and Manickam A** (2009) Biochemical Methods. New Age International Pvt. Ltd. New Delhi. 11. **Segel I H** (2010) Biochemical Calculations. John Wiley and Sons, California, USA. 12. **Sheehan D** (2009) Physical Biochemistry: Principles and	

	Applications. John Wiley and Sons Ltd, Chichester, England. 13. **Verma P, Ashish S** (2014) Laboratory Manual for Biotechnology. S. Chand and Company Pvt. Ltd., New Delhi. 14. **Wharton, David** (1972) Experiments and Methods in Biochemistry. The Macmillan Co., London. 15. **Wilson K and Walker J** (2010). Principles and Techniques of Biochemistry and Molecular Biology. Cambridge University Press, UK.	
Learning Outcomes:	Students will be able to develop competence in handing various biochemical techniques and apply them in isolating and analyzing different biological molecules.	

Programme: M.Sc. (Botany)
Course Code: BOO-453
Title of the Course: Introduction to Omics
Course Credit: 3
Effective from AY: 2020-2021

Prerequisite for the Course:	Should have basic knowledge of structure of genome, genes, structure of proteins, metabolism.	
Objective:	This course will make students familiarize with terminology, underlying principals and methodology in genomics, transcriptomics, proteomics and metabolomics. Thrust of the paper is Protein dynamics, protein trafficking machinery and autophagy for protein turnover. The role of protein networks in mediating cellular responses and transmitting signals will be highlighted with emphasis on giving relevant examples for the use in future research work.	
Content:	**1. Genomics:** Classical genomics, Mendelian Genetics, Forward/Reverse Genetics, Linking Genotype and phenotypes, use of mutants. Large Scale genomic Sequencing: Platforms for next generation sequencing (NGS), whole genome sequencing, targeted sequencing, ChIP sequencing, Applications of Genome sequencing. Epigenetic regulation in Plants, DNA methylation, Histone modification, Plant Mediator Complex. Transcriptomics: Differential expression, Alternate splicing, RNA sequencing, ENCODE, Epigenomic analysis. **2. Proteomics:** Protein structure and function, amino acids, peptides, protein synthesis. Post translational modification of proteins: Glycosylation, Phosphorylation, Acetylation, Methylation, Ubiquitinylation, Identification of post-translational modification in proteins, protein phosphorylation assay. Protein transport and Secretion, Protein targeting and trafficking, ER Golgi dynamics in protein sorting, dynamics of membrane bound protein, mechanism of protein secretion. Protein degradation: Ubiquitin-proteosome pathway, Lysosomal Proteolysis, role of autophagy and vesicular trafficking in degradation of protein. Essentials of Protein-protein interaction: Protein interacting motifs, multi-protein complex, application of protein interactions, databases and tools to study Protein interactome. Protein Networks in Plant signaling: Introduction to plant signaling, types of membrane receptors (Membrane receptors, intracellular and extracellular receptors, G-protein coupled receptors, ion channels, Pattern recognition receptors), components of cell signaling (secondary messengers, sensors and effectors, Two-component system, signal perception), Types of signaling pathways, reversible phosphorylation and dephosphorylation, role of plant signaling in development and immunity.	11 hours 18 hours

	3. Metabolomics: Overview of Metabolites, basics of metabolic pathways, errors of metabolism, sample preparation, extraction, derivatization, Targeted v/s untargeted metabolomics, Identification of molecular features and metabolites, structural confirmation, application of metabolomics in diagnosis.	7 hours
Pedagogy:	Lectures/Tutorials/Seminars/Assignment/Self study	
References/ Readings:	**António, C.** (2018) Plant Metabolomics- Methods and Protocols, Humana press, Hertfordshire, UK. **Cooper, G.M.** (2000) The Cell: A Molecular Approach. 2nd edition. Sunderland (MA): Sinauer Associates, UK. **Karp, G.** (2009) Cell and molecular biology: Concepts and experiments, 7th edition. John Wiley & Sons, USA. **Kramer, I. M.** (2015) Signal Transduction, 3rd edition, University of Bordeaux, Talence, France. **Nelson, D. L., Cox, M. M., & Lehninger, A. L.** (2013) Principles of biochemistry (p. 245), Freeman, New York. **Primrose, S. B. and Twyman, R. M.** (2006) Principles of gene manipulation and genomics, Blackwell Publishing, Australia. **Reece, R. J.** (2004) Analysis of genes and genomes. John Wiley & Sons Ltd. **Saraswathy, N. and Ramalingam, P.** (2011) Concepts and Techniques in Genomics and Proteomics. Biohealthcare Publishing (Oxford) Limited, New York. **Segev, N.** (2009) Trafficking Inside Cells, Springer science Business media, USA. **Sessa, G.** (2012) Molecular Plant Immunity. John Wiley & Sons, Inc, Isarel. **Voet, D., Voet, J. G. and Pratt, C. W.** (2016) Fundamentals of biochemistry: life at the molecular level. John Wiley & Sons, USA. **Walker, J. M. and Rapley, R.** (2008) Molecular Biomethods Handbook, Hertfordshire, UK. **Wilson, K. and Walker, J.** (2010) Principles and techniques of biochemistry and molecular biology, 7th edition. Cambridge University Press, UK.	
Learning outcome:	Students will get familiar with principles and applications in Genomics, Transcriptomics, Proteomics and Metabolomics. They will be able to apply basic concepts in research work.	

Programme: M. Sc. (Botany)
Course Code: BOO- 501
Title of the Course: Fungal Chemistry and Mycoremediation.
Number of Credits: 1
Effective from AY: 2020-21

Prerequisites for the course:	Background of mycology, ecology and chemoinformatics.	
Objective:	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.	
Content:	**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. **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,	**1 hour** **1 hour**

	Ergosterol, Fusidane Steroidal Antibiotics, Viridin, Wortmannin and their Relatives, Triterpenoids of the basidiomycetes, Meroterpenoids. **3. Fungal Metabolites Derived from the Citric Acid Cycle:** Introduction, Citric Acid and Related Acids, Fungal Tetronic Acids, Canadensolide and Avenaciolide, Nonadrides, Squalestatins. **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. **5. Mycotoxins:-**Introduction, Ergotism, Trichothecenes as Mycotoxins, Other Fusarium Toxins, Aflatoxins, Mycotoxins of Penicillium Species, PoisonousMushrooms. **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. **7.** Fungal Treatment of Industrial Wastewaters, Distillery and Brewery Wastes. **8.** Fungal Metabolism of Petroleum Hydrocarbons, Phenols, Chlorophenols, Pentachlorophenol, Polycyclic Aromatic Hydrocarbons. **9.** Fungal Degradation of Polychlorinated Biphenyls and Dioxins, Pesticides. **10.** Fungal Lignin Degradation, Decolorization of Pulp and Paper Mill Effluents, Decolorization and Degradation of Dyes. **11.** Fungal Biosorption of Heavy Metals.	**1 hour** **2hours** **1 hour** **1 hour** **1 hour** **1 hour** **1 hour** **1 hour**
Pedagogy:	Lectures/ tutorials/seminars/ Moodle based guidance/Expert lectures/Videos/Assignments/Self-Study	
References/Readings	1. **Hanson, James**. (2008). The chemistry of fungi, Royal Society of Chemistry, 221 pp. 2. **Harbhajan Singh**. (2006). Mycoremediation: Fungal bioremediation, Wiley, 608 pp. 3. **Claudio Toniolo and Hans Brockner**.	

	(2009). Peptaibiotics: Fungal Peptides Containing alpha-Dialkyl alpha-Amino Acids, Wiley-VCH, 714 pp. 4. **Frisvad.** (1998), Chemical fungal taxonomy, CRC press, 424 pp. 5. **Volesky B.** (1990). Biosorption of heavy metals, CRC press, 408 pp. 6. **Milbra A. Schweikert and Bruce B. Jarvis** (Eds.).(2003). Handbook of Secondary Fungal Metabolites, 3-Volume Set, Academic Press, 2498 pp. 7. **Kuhn P. J.** (1990). Biochemistry of Cell Walls and Membranes in Fungi, Springer, 327 pp. 8. **G. D. Robson, Pieter van West and Geoffrey Gadd** (Eds.). (2007). Exploitation of Fungi (British Mycological Society Symposia), CUP, 350 pp. 9. **G. M. Gadd**.(2001). Fungi in Bioremediation (British Mycological Society Symposia), CUP, 496 pp. 10. **Valdes J.V.** (2000). Bioremediation, Springer, 169 pp. 11. **Zhigiang A.N.** (2005). Handbook of Industrial Mycology, CRC Press, 763 pp. 12. **S. K. Deshmukh and M.K.Rai.** (2005). Biodiversity of fungi: their role in human life, Science Publishers, 460 pp. 13. **G. M. Gadd.** (2006). Fungi in biogeochemical cycles, Volume 24 of British Mycological Society symposium series, CUP, 406 pp.	
Learning Outcomes	1. Being able to work in industries using fungi for metabolite production or bioremediation. 2. Learn fungal chemical creativity and acquire skills in fungal bioprospecting. 3. Get suitable employment as fungal biochemist/Mycochemist.	

Programme: M. Sc. (Botany)
Course Code: BOO- 502
Title of the Course: Lab in Fungal Chemistry and Mycoremediation.
Number of Credits: 1(24 hours)
Effective from AY: 2020-21

Prerequisites for the course:	Knowledge of basic mycology, instrumental techniques, basic microbiogical and microscopic techniques	

Objective:	To impart knowledge on chemical creativity of fungi especially from industrial and environmental bioremediation angles	
Content:	**1**. UV -Visible Spectrosopic analysis of any four fungal cultures. **2**. Extraction of Melanin from Melanogenic cultures. **3.** Extraction of organic acids from *Aspergillus niger* culture filtrate. **4.** Microincineration technique for detecting calcium oxalate from fungi. **5.** Use of Dragendorff reagent for Detection of fungal alkaloids. **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 of leather, paint films *etc.* **12.** Isolation of fungi from cashew feni production waste. **13.** Screening cultures for Bavendam's reaction on Tannic acid agar. **14.** Detection of fungal lignocellulolytic hydrolytic enzymes *e.g.* Laccase, ligninase, cellulose. **15.** Detection of other fungal hydrolytic enzymes amylases, proteases, urease. **16**. Detection of fungal lipolytic enzymes -lipases, esterases *etc.* **17**. Evaluation of Fungal growth in any six non polar organic solvents (any two cultures). **18.** Fungal growth on polluting tar balls and polystyrene foam (any two cultures). **19.** Fungal biodecolourization of common textile dyes (any two cultures, any one dye). **20.** Using fungal biomass for biosorption of Iron (any two cultures). **21.** Oxygen Bubble entrapment assay for fungal catalase (any two cultures).	**Each session of 2 hours, any 12 sessions**
Pedagogy:	Field work, Lab exercizes, Mini projects, Hands on exercizes and demos, Assignments/Self-study/Moodle based guidance/Videos.	
References/Readings	**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.	
Learning Outcomes	1. Being able to work as fungal chemist or bioprospector. 2. Being able to work in companies using fungi as agents for bioremediation or secondary metabolite production. 3. Being able to establish industry based on fungal chemical products.	

Programme: M. Sc. (Botany)
Course Code: BOO- 503
Title of the Course: Glycobiology
Number of Credits: 1
Effective from AY: 2020-21

Prerequisites for the course:	Good knowledge of chemistry, biology and biochemistry at UG level.	
Objective:	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.	
Content:	**1.General Principles:** Historical Background and Overview, Saccharide Structure and Nomenclature, Exploring the Biological Roles of Glycans. **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. **3.Protein-Glycan interactions:**Discovery and Classification of Animal, Plant and fungal Lectins, Selectins, Galectins, Microbial Carbohydrate-binding Proteins, Plant Lectins, their Classification , Structure, Uses and functions; Fungal lectins, their structural diversity,biological functions, molecular characterization. **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. **5. Future perspectives**:-Glycogenes, glycoscience and rational drug design.	**1hour** 3 **hours** 3 **hours** 4 **hours** 1 **hour**
Pedagogy:	Lectures/Tutorials/Seminars/Videos/Moodle based guidance/Assignments/Self-Study	
References/Readings	1. **Ajit Varki** 2002. Essentials of glycobiology, Cold Spring Harbour Laboratory Press. 2. **R R Townsend and A T Hotchkiss.** 1997. Techniques in glycobiology, TF-CRC. 3. **S. A.Dwek and M. V. Schumacher**. 2002. Functional and Molecular Glycobiology, Brooks,	

U.PAP Edition.
4. **Fukuda, Minoru**, **Hindsgaul and Ole** 2000. Molecular and Cellular Glycobiology, Paperback Edition.
5. **Thisbe K. Lindhorst. 2007.** Essentials of Carbohydrate Chemistry and Biochemistry, Wiley.
6. **Valentin Wittmann. 2007.** Glycopeptides and Glycoproteins - Synthesis, Structure, and Application Edited, Springer.
7. **Marco Brito-Arias.** 2007. Synthesis and Characterization of Glycosides, Springer.
8. **Maureen E. Taylor and Kurt Drickamer.** 2002. Introduction to Glycobiology, OUP.
9. **Natan Sharon, Halina Lis and Springer**. 1999. Lectins**.**
10. **R. Doyle, CRC.** 1994**.** Lectin-Microroganism interaction.
11. **Ginsburg V.** 1972. Complex Carbohydrates, Part B. Methods Enzymol., Vol 28. Academic Press, San Diego, California.
12. **Gottschalk A.** 1972. Glycoproteins: Their composition, structure and function. Elsevier, New York.
13. **Ginsburg V.** 1978. Complex carbohydrates, Part C. Methods Enzymol., Vol. 50. Academic Press, San Diego, California.
14. **Lennarz W.J.**, 1980. The biochemistry of glycoproteins and proteoglycans. Plenum Press, New York.
15. **Ginsburg V. and Robbins P.** 1981. Biology of carbohydrates, vol. 1. Wiley, New York.
16. **Ginsburg V.** 1982. Complex carbohydrates, Part D. Methods Enzymol., vol. 83. Academic Press, San Diego, California.
17. **Horowitz M. and Pigman W.** 1982. The glycoconjugates. Academic Press, New York.
18. **Schauer R.,** 1982. Sialic acids, chemistry, metabolism, and function. Springer-Verlag, New York.
19. **Ivatt R.J.** 1984. The biology of glycoproteins. Plenum Press, New York.
20. **Ginsburg V. and Robbins P**. 1985. Biology of carbohydrates, vol. 2. Wiley, New York.
21. **Beeley J.G.** 1985. Glycoprotein and proteoglycan

	techniques. Elsevier, Amsterdam, The Netherlands. 22. **Liener I.E., Sharon N., and Goldstein I.J.** 1986. The lectins: Properties, functions, and applications in biology and medicine. Academic Press, Orlando, Florida. 23. **Feizi T.** 1989. Carbohydrate recognition in cellular function. Ciba Foundation Symposium, vol. 145. Wiley, New York. 24. **Ginsburg V. and Robbins P.** 1991. Biology of carbohydrates, vol. 3. Wiley, New York. 25. **Fukuda M.,** 1992. Cell surface carbohydrates and cell development. CRC Press, Boca Raton, Florida. 26. **Allen H.J. and Kisailus E.C.** 1992. Glycoconjugates: Composition, structure, and function. Dekker, New York. 27. **Fukuda M.** 1992. Glycobiology: A practical approach. IRL Press, Oxford, United Kingdom. 28. **Lennarz W.J. and Hart G.W.** 1994. Guide to techniques in glycobiology. Methods Enzymol., vol. 230. Academic Press, San Diego, California. 29. **Bock K. and Clausen H.** 1994. Complex carbohydrates in drug research: Structural and functional aspects. Munksgaard, Copenhagen, Denmark. 30. **Fukuda M. and Hindsgaul O.** 1994. Molecular glycobiology. Oxford University Press, New York. 31. **Alavi A. and Axford J.S.** 1995. Advances in experimental medicine and biology, vol. 376, Glycoimmunology. Plenum Press, New York. 32. **Montreuil J., Vliegenthart J.F.G. and Schachter H.** 1995. Glycoproteins. Elsevier, New York. 33. **Verbert A.** 1995. Methods on glycoconjugates: A laboratory manual. Harwood Academic Publishers, Switzerland. 34. **Townsend R.R. and Hotchkiss A.T.** 1997. Techniques in glycobiology. Marcel Dekker, New York. 35. **Iozzo R.** 2000. Proteoglycans: Structure, biology and molecular interactions. Marcel Dekker, Inc., New York.	
Learning Outcomes	1. Be able to understand the role of glycans in biosphere and biotechnology. 2. Being able to understand role of glycans in health and disease and medicinal field. 3. Having Prospects to work in pathology and	

	hematological laboratories.	

Programme: M. Sc. (Botany)
Course Code: BOO- 504
Title of the Course: Lab in Glycobiology
Number of Credits: 1(24 hours sessions)
Effective from AY: 2020-21

Prerequisites for the course:	Basic knowledge of carbohydrate chemistry, biochemistry, cell biology, Spectroscopy	
Objective:	To impart training in various aspects of glycobiology.	
Content:	**1.** Simple chemical tests to detect biological glycans. **2.** Extraction of exocellular polysaccharides (EPS) from yeasts/fungi. **3.** Quantitative Extraction of starch from plant storage organs. **4**. Extraction of soluble lectins from any one plant and fungal source. **5.** Study of plant gums/Acidic polysaccharides. **6.** Haemagglutination reaction/assays with any one plant and fungal lectins. **7.** Application of IR-spectroscopy for characterizing polysaccharides. **8.** Immobilization and use of amylase. **9.** Glycomics databases.	**4 hours** **4 hours** **4 hours** **2 hours** **2 hours** **2 hours** **2 hours** **2 hours** **2 hours**
Pedagogy:	Practical exercises, mini projects, hands on demos, videos, moodle based guidance.	
References/Readings	1. **R R Townsend and A T Hotchkiss.** 1997. Techniques in glycobiology, TF-CRC. 2. **Thisbe K. Lindhorst. 2007.** Essentials of Carbohydrate Chemistry and Biochemistry, Wiley. 3. **Ginsburg V. and Robbins P.** 1981. Biology of carbohydrates , vol. 1. Wiley, New York. 4. **Fukuda M.** 1992. Glycobiology: A practical approach. IRL Press, Oxford, United Kingdom. 5. **Lennarz W.J. and Hart G.W.** 1994. Guide to techniques in glycobiology. Methods Enzymol., vol. 230. Academic Press, San Diego, California. 6. **Verbert A.** 1995. Methods on glycoconjugates: A laboratory manual. Harwood Academic Publishers, Switzerland. 7. **Townsend R.R. and Hotchkiss A.T.** 1997. Techniques in glycobiology. Marcel Dekker, New	

	York.	
Learning Outcomes	1. Better understanding of practical techniques in glycbiology useful in analytical labs. 2. Better prospects for employment in pathology or hematology/blood/tissue typing labs or vaccine production units. 3. Better prospects of job in pharma industry.	

Programme: M. Sc. (Botany)
Course Code: BOO- 505
Title of the Course: Fungal Biodiversity, Bioprospecting and Biotechnology
Number of Credits: 3
Effective from AY: 2020-21

Prerequisites for the course:	Knowledge of fungi and fungal biotechnology at UG Level.	
Objective:	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.	
Content:	1. 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. 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; 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.	**12 hours**

	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 strainspreliminary and high throughput screening (HST); leads and lead optimization. **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, 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.	**8 hours** **16 hours**

Pedagogy:	Lectures/ Tutorials/Seminars/Videos/Moodle Based Assignments/Assignments/Self-Study	
References/Readings	1.**Nair, L. N.** (2007). Topics in Mycology and Pathology, New Central Book agency, Kolkata. 2.**Oliver R. P. and Michael Schweizer** (1999). Molecular Fungal Biology, CUP. 3.**Berry D. R.** (1988). Physiology of industrial Fungi, Blackwell Scientific Publishers. 4.**Zhingiang Ann** (2005). Handbook of Industrial Mycology, CRC Press. 5.**Annonymous**(2006). Handbook of the Convention on Biological Diversity, CBD secretariat, earthscan. 6.**Satyanarayana T. and Johri B.N.** (2005). Microbial Diversity, Current Perspectives and Potential Applications, IK international. 7.**Gregory Michael Mueller, Gerald F. Bills and MercedesS. Foster** (2004). Biodiversity of fungi: inventory and monitoring methods, Academic Press. 8.**Arora Dilip K.** (2004). Fungal biotechnology in agricultural, food, and environmental applications, CRC Press. 9.**Jan S. Tkacz and Lene Lange** (2004). Advances in fungal biotechnology for Industry, Agriculture, and Medicine, Springer. 10.**Alan T.Bull** (2004). Microbial Diversity and Bioprospecting, ASM Press. **11.Robson, G. D., Pieter van West and Geoffrey Gadd** (Eds.) (2007). Exploitation of Fungi (British Mycological Society Symposia), CUP, 350 pp.	
Learning Outcomes	1. Being able to grasp advanced concepts in fungal biotechnology, genomics and proteomics, 2.Being able to identify emerging areas of research and development in fungal bioprospecting and biotechnology, 3. Better capacity to assist in local fungal biodiversity registers and fungal aspects of ATBI, 4. Establish and manage accredited Fungus culture collections and contribute to local efforts of fungi habitat conservation.	

Programme: M. Sc. (Botany)
Course Code: BOO-506
Title of the Course: Lab in Fungal Biodiversity, Bioprospecting and Biotechnology.
Number of Credits: 1 (24 hrs session)
Effective from AY: 2020-21

Prerequisites for the course:	Knowledge of fungi and fungal biotechnology at UG Level.	
Objective:	To introduce students to practical knowledge and hands on training in various areas of fungal biodiversity surveys, systematic chemical screening of important strains and impart technical knowledge in fungal bioprospecting and biotechnology to make them skilled in biotechnology based industries in general and those using fungi in particular	
Content:	1. Using fungal databases e.g. indexfungorum.org 2. Introduction to Fungal biodiversity inventorying methods. 3. Constructing fungal phylogenetic tree. 4. Production of fungal pellets in submerged culture. 5. Studying Morphology of fungal pellets. 6. Screening *Aspergillus* strains for organic acid production. 7. Testing fungal cultures for Phosphate solubilization assay using Pikovskaya medium. 8. Screening yeasts for sugar fermentation capacity. 9. Extraction and UV-Visible spectral detection of pigments from fungi. 10. Study of fungal melanins. 11. Fungal enzyme assays using chromogenic methods. 12. Producing and testing immobilized fungal biomass. 13. Immobilization of fungal enzymes. 14. Studying fermentation of grape juice with wine yeast. 15. Production of mushroom spawn and assessment of its quality. 16. Quality parameters of marketed mushrooms. 17. Testing action of fungicides on fungal cultures. 18. Testing Dough raising power of Bakers' yeast. 19. Tests to detect fungal siderophores. 20. Study of Nickel uptake by fungal cultures.	**All two hour sessions, any 2 sessions of two hours each from 1-3, any 4 from 4 to 10, any 5 sessions from 11-18 and any 1 from 19 and 20**
Pedagogy:	Practicalexercises/ field and lab//demos/hands on exercises/ video tutorials/ software tools/mini projects/seminars/industrial study visits	
References/Readings	1. **Satyanarayana T. and Johri B.N.** (2005). Microbial	

	diversity, Current Perspectives and Potential Applications, IK international. 2. **Gregory Michael Mueller, Gerald F. Bills and Mercedes S. Foster** (2004). Biodiversity of fungi: inventory and monitoring methods, Academic Press. 3. **Arora Dilip K.** (2004). Fungal biotechnology in agricultural, food, and environmental applications, CRC Press. 4. **Jan S. Tkacz and Lene Lange** (2004). Advances in fungal biotechnology for Industry, Agriculture, and Medicine, Springer. 5. **Alan T.Bull** (2004). Microbial Diversity and Bioprospecting, ASM Press. 6. **Robson, G. D., Pieter van West and Geoffrey Gadd** (Eds.) (2007). Exploitation of Fungi (British Mycological Society Symposia), CUP, 350 pp.	
Learning Outcomes	• Enable the students to adopt necessary skills required for preparing fungal biodiversity inventories • Enable the students to get employment in biotechnology industries based on fungi • Students would be able to independently do high throughput screening of industrial strains of fungi	

Programme: M. Sc. (Botany)
Course Code: BOO-507
Title of the Course: Mycological Techniques.
Number of Credits: 3
Effective from AY: 2020-21

Prerequisites for the course:	Knowledge of basic mycology/microbiology at UG level	
Objective:	Introduce students to important techniques in basic and applied mycology.	
Content:	**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	**12 hours**

	habitat;, 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. **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. **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; 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.	**12 hours** **12 hours**

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

	18. **Sathe A. V., Deshpande S. , Kulkarni, S. M. and J. Daniel.** (1980). Agaricales (mushrooms) of south west India, MACS, Pune.	
Learning Outcomes	1. Being able to work in a mycological laboratory 2. Being able to work in a pharma industry using fermentation technology 3. Being able to work as fungal bioprospector 4. Being able to contribute in management of fungal culture collections.	

Programme: M. Sc. (Botany)
Course Code: BOO-508
Title of the Course: Lab in Mycological Techniques.
Number of Credits: 1(Total 24 sessions)
Effective from AY: 2020-21

Prerequisites for the course:	Knowledge of basic mycology, microbiological and microscopic techniques, fungal taxonomy.	
Objective:	To impart training in modern mycological techniques appropriate to industrial and economic needs.	
Content:	**1**. Collection of fungal samples from diverse habitats and recording of field data, **2.** Preparation of mycological herbarium. **3.** Examining fungal ramification of plant litter **4**. Use of different stains and optical brighteners in mycology. **5.** Photomicrography of interesting fungi, digital image analysis, 6. Taxonomic drawings of fungi using drawing tube. **7**. Isolation of fungal cultures from diverse samples. **8.** Use of fungal taxonomic keys and electronic databases, writing a taxonomic diagnosis. **9.** Somatic pairing tests using pure cultures of higher fungi. **10.** Evaluation of colony growth on solid media **11**. Evaluation of colony growth in liquid media **12.** Analysis of submerged biomass and culture filtrate from shaken cultures. **13.** Hemocytometric counts of fungal spores. **14.** Measurement of hyphal growth rate and Fractal dimensions of colonies **15.** Use of micromanipulator for single spore isolation.	**Any 12 sessions, Each session of 2 hrs**

	16. Fungal protoplast production, fusion and regeneration using commercial lytic enzymes. **17.** Effect of light on growth of fungal cultures and pigment production. **18**. Antibiotic assays using fungal extracts. **19**. Studying cultural holomorphs (anamorph-teleomorph connection) in lab. **20**. Extraction of fungal DNA, RNA, Proteins. **21.** Introduction to fungal bioinformatics	
Pedagogy:	Hands on exercizes, miniprojects, field work, demos, videos, moodle based guidance, workshops	
References/Readings	1. **S. Sundar Rajan.** (2000). Practical Manual of Fungi, Anmol Publications, New Delhi. 2. **Nair, L.N.** (2007). Topics in Mycology and Pathology, new central Book agency, Kolkata. 3. **E.W. Koneman and G.W. Roberts.** (1985).Practical laboratory Mycology, Williams and Wilkins. 4. **A.Johnston and C. Booth.**(1983). Plant pathologist's pocketbook, CAB, UK. 5. **A.Booth.** (1971). Methods in Microbiology, Volume 4, Academic Press. 6. **E. Glyn V. Evans and M.D. Richardson.** (1989). Medical Mycology : A practical approach, IRL Press. 7. **Bridge, P.D.** (1998). Applications of PCR in Mycology, CABI, UK. 8. **Manuel A. S. Graça, Felix Bärlocher and Mark O. Gessner.** (2005). Methods to study litter decomposition: a practical guide, Springer. 9. **Maheshwari and Ramesh.** (2005), Fungi: experimental methods in biology, CRC Press. 10. **Rossman Amy R.** (1998). Protocols for an all taxa biodiversity inventory of fungi in a Costa Rican conservation area, Parkway Publishers, Inc. 11. **Oliver R. P. and Michael Schweizer.** (1999). Molecular fungal biology, CUP. 12. **Berry D. R.** (1988). Physiology of industrial Fungi, Blackwell Scientific Publishers. 13. **Moore David and LilyAnn Noval Frazer.** (2002). Essential Fungal genetics, Springer. 14. **Harry J. Hudson.**(1986). Fungal biology, ELBS/Edwin Arnold, UK. 15. **Deacon, J.W.** (1984). Introduction to Modern	

	Mycology, ELBS, Blackwell scientific publications. 16. **Hawksworth, D.L., P.M. Kirk, B.C. Sutton and D.N.Pegler.** (1995). Ainsworth and Bisby's Dictionary of the fungi, 8th edition, CAB international. 17. **Heather Angel.** (1975). Photographing Nature-Fungi, Fountain Press, UK. 18. **J.D. Desai and A.J.Desai** (1980). Methods in Microbiology-Microscopy and Staining, Prashant Pub. 19. **Bhat, D. J.** (2010). Fascinating Microfungi (hyphomycetes) of Western Ghats-India, Broadway Book Centre, Goa. 20. **Sathe A.V., Deshpande S. , Kulkarni, S.M. and J. Daniel.** (1980). Agaricales (mushrooms) of south west India, MACS, Pune.	
Learning Outcomes	**1.** Being able to work as a mycologist. **2.** Being able to contribute to fungi based drug discovery programme. **3.** Being able to contribute to fungal biodiversity inventories.	