

**DRAFT COURSE STRUCTURE OF M. Sc. SYLLABUS
TO BE IMPLEMENTED (Semester I & II) FROM July 2014
AND (Semester III & IV) FROM July 2015**

Semester - I		(24 cr.)
Course No.	Title of course	Credits allotted
BO1.1	Taxonomy I (Algae, Fungi, Bryophytes)	4C
BO1.2	Physiology	4C
BO1.3	Genetics and Breeding	4C
BO1.4	Practicals on BO1.1	6C
BO1.5	Practicals on BO1.2	3C
BO1.6	Practicals on BO1.3	3C
Semester - II		(26C)
BO2.1	Taxonomy II (Pteridophytes, Gymnosperms)	4C
BO2.2	Cell Biology	4C
BO2.3	Molecular Biology	4C
BO2.4	Ecology	4C
BO2.5	Practicals on BO2.1 and BO2.4	[2.5C (BO2.1) 2.5C (BO2.4)] 5C
BO2.6	Practicals on BO2.2 and BO2.3	[2.5C (BO2.2) 2.5C (BO2.3)] 5C
Semester - III		(26C)
BO3.1	Taxonomy III (Angiosperms)	4C
BO3.2	Development	4C
BO3.3	Tools and techniques	4C
BO3.4	Specialization course Paper 1	4C
BO3.5	Practicals on BO3.1 and BO3.2	[2C (BO3.1) 2C (BO3.2)] 4C
BO3.6	Practicals on BO3.3	3C
BO3.7	Practicals on BO3.4	3C
Semester - IV		(24C)
BO4.1	Quantitative Methods and Bioinformatics	4C
BO4.2	Specialization course Paper 2	4C
BO4.3	Project on BO4.2	8C
BO4.4	Practicals on BO4.1	4C
BO4.5	Practicals on BO4.2	4C
SPECIALIZATION COURSES PAPER I and II		
4C theory, 3C practicals (3 rd Sem) 4C theory, 4C practicals (4 th Sem)		
BO 3.4a and 4.2a Pharmacognosy		
BO3.4b and 4.2b Ecophysiology		
BO3.4c and 4.2c Plant Biotechnology		
BO3.4d and 4.2d Biodiversity and Bioprospecting – Algae, Fungi		
BO3.4e and 4.2e Biodiversity and Bioprospecting – Angiosperms		

BO 1.1 - Taxonomy (Algae, Fungi, Bryophytes)	4C
Credits-1.5	22L
1. Algae and their position in “Domains and Kingdoms” System, Trends in classification of algae.	2L
2. Cyanophyta: Ultrastructure; strategy of cell division; thallus organization, heterocyst.	3L
3. Brief introduction, structural and reproductive features of Chrysophyta, Xanthophyta, Bacillariophyta, Dinophyta.	4L
4. Chlorophyta – structure and evolution of thallus, unicellular eukaryotes (endosymbiotic theory), morphogenesis in <i>Acetabularia</i> , reproduction and life histories with reference to orders of green algae.	5L
5. Charophyta and Euglenophyta: structure and reproduction and interrelationship	2L
6. Phaeophyta: general account of morphology, anatomy, reproduction and life histories.	3L
7. Rhodophyta: classification, thallus structure, reproduction, reproductive strategies and life histories.	3L
Credits - 1.5	23L
1. Taxonomy of fungi: Characters of fungi used of classification, various systems of classification of fungi.	3L
2. Chromista – Its present status in classification; general characters, classification up to orders. Lichen: types, morphology and reproduction.	4L
3. Fossil fungi: Occurrence and their significance.	1L
4. An outline of latest classification system proposed by Ainsworth or Alexopoulos	3L
2. Myxomycotina: structure, life cycle patterns of major classes	1L
3. Mastigomycotina: structure, life cycle patterns of major classes.	2L
4. Zygomycotina: structure, thallus organization, evolution of sexual reproductive structures.	2L
5. Ascomycotina: thallus organization, centrum development, different types of ascocarps	3L
6. Basidiomycotina: tissue differentiation, development of basidia and basidiospore	2L
7. Deuteromycotina: types of conidial ontogeny and fruit body organization	2L

Credit - 1	15L
1. Taxonomy of Bryophytes: Morphological characters used for classification; Systems of classification of Bryophytes.	1L
2. Distribution, morphological, anatomical, reproductive studies and comparative account of sporophytes and gametophytes and interrelationships along with their fossil relatives of the following orders:	
a. Sphaerocarpales, Calobryales, Takkakiales	2L
b. Marchantiales	2L
c. Jungermanniales	3L
d. Anthocerotales	1L
e. Sphagnales	1L
f. Andraeales	1L
g. Polytrichales, Buxbaumiales	2L
h. Eubryales, Funariales	2L

References- Algae:

1. Brodie, J. and Lewis, J. (2007). (Ed.) Unravelling the algae: the past, present and future of algal systematics. CRC press, New York, pp. 335.
2. Bellinger, E. G. and Sigee, D. C. (2010). Freshwater algae: Identification and use as bioindicators. Wiley-Blackwell, UK, pp. 271.
3. Cole, K. M. and Sheath, R. G. (1990). *Biology of the red algae*. Cambridge University Press. USA, Pp. 503.
4. Desikachary, T.V. (1959). *Cyanophyta*. ICAR, New Delhi.
5. Graham, L. E. and Wilcox, L. W. (2000). *Algae*. Prentice-Hall, Inc. pp. 640.
6. Krishnamurthy, V. (2000). Algae of India & neighbouring countries I. Chlorophycota, Oxford & IBH, New Delhi.
7. Lee, R. E. (2008). *Phycology*. Cambridge University Press, pp. 547.
8. Misra, J. N. (1966). *Phaeophyceae in India*. ICAR, New Delhi.
9. Prescott, G. W. (1969). *The algae: A review*. Nelson, London.
10. Smith, G. M. (1950). *The fresh water Algae of the United States*, Mc-graw Hill, Newyork.
11. Srinivasan, K. S. (1969) *Phycologia India*. Vol I & Vol II B.S.I. Calcutta.

References – Fungi:

1. Alexopolus, C. J., Minms, C. W. and Blackwell, M. (1999). (4th edn) *Introductory Mycology*. Wiley, New york. Alford, R. A..
2. Deacon, J. W. (2006). *Fungal biology*. (4th Ed.) Blackwell publishing, ISBN. 1405130660.

3. Kendrick, B. (1994). *The fifth kingdom* (paperback), North America, New York, Publisher: 3rd edition, ISBN- 10: 1585100226.
4. Kirk et al., (2001). *Dictionary of the fungi*, 9th edition, published Wallingford : CABI, ISBN: 085199377X.
5. Mehrotra, R. S. and Aneja, K.R. (1990). *An introduction to mycology*. New age publishers, ISBN 8122400892.
6. Miguel U., Richard, H. and Samuel, A.(2000). *Illustrated dictionary of the Mycology*, Elvira Aguirre Acosta, Publisher: St. Paul, Minn: APS press, ISBN 0890542570.
7. Webster, J. and Rpland W. (2007). *Introduction to fungi*. (3rd Ed.), Cambridge University Press, 978-0-521-80739-5.

Reference- Bryophytes:

1. Cavers, F. (1976). *The inter relationships of the bryophyte*. S.R. Technic, Ashok Rajpath, Patna.
2. Chopra, R. N. and Kumar, P. K. (1988). *Biology of bryophytes*. John Wiley&Sons, New York, NY.
3. Kashyap, S. R. (1932). *Liverworts of the Western Himalayas and the Panjab plain* (illustrated): Part 2 The Chronica Boanica New Delhi.
4. Kashyap, S. R. (1929). *Liverworts Of The Western Himalayas And The Panjab Plain Part 1* Chronica Botanica New Delhi.
5. Parihar, N. S. (1980). *Bryophytes: An introduction to Embryophyta Vol I*, Bryophya central Book Depot.
6. Prem puri (1981). *Bryophytes: Morphology, Growth and Differentiation*, Atma ram and Sons, New delhi.
7. Udar, R. (1975). *Bryology in India*: Chronica Botanica Co., [c], New Delhi.
8. Udar, R. (1970). *Introduction to bryophyta* Shashidhar Malaviya Prakashan Lucknow
9. Watson, E. V. (1971). *Structure and life of bryophytes 3rd*, Hutchinson University Library London.

BO 1.2 – Physiology **4C**

Credit 1 –

Structure and properties of water, its biological significance. Ionization of water, pH, buffers **3L**

Bioenergetics – free energy, changes in free energy during chemical reactions, entropy and enthalpy, high energy compounds, synthesis of ATP, activation energy **2L**

Building blocks of biological macromolecules – amino acids, sugars, fatty acids, purine and pyrimidine bases. Their biosynthesis and metabolism. **5L**

Structure, biosynthesis and metabolism of polysaccharides, lipids, proteins and nucleic acids. **5L**

Credit 2-

Water uptake, transport and transpiration. Stomatal physiology **3L**

Uptake and assimilation of nitrogen, enzymes involved, biological nitrogen fixation **3L**

Mineral nutrition of plants, Ion transport – passive and active **5L**

Translocation of photoassimilates, transport in phloem, Source and sink relationship **4L**

Credit 3 –

Photosynthesis – Photosynthetic pigments, organization of photosynthetic electron transport system in thylakoid membranes. Charge separation and electron transport, fluorescence and photochemistry, oxygen evolution, NAPD reduction, photophosphorylation. **5L**

Reduction of carbon dioxide - RuBPCase and Calvin cycle, photorespiration. CO₂ concentrating mechanisms in C₄ and CAM plants. **4L**

Respiration – Glycolysis, citric acid cycle, pentose phosphate pathway. Organization of mitochondrial electron transport system, ATP synthesis. Respiratory control Anaerobic respiration **6L**

Credit 4 –

Plant growth hormones – Structure, biosynthesis and metabolism of auxins, cytokinins, gibberellins, abscisic acid and ethylene. Physiological role of hormones **8L**

Photoperiodism and vernalization. Tropic and nastic movements in plants **4L**

Secondary metabolites – Terpenoids, phenolics, alkaloids. Major secondary metabolite synthesis pathways in plants. Role of secondary metabolites **3L**

References :

1. Berg J.M., Tymoczko J.L., Stryer L. (2002) Biochemistry. 5th Ed. Wlt. Freeman and Company, New York.
2. Buchanan B.B., Gruissem W., Jones R.L. (2000) Biochemistry and Molecular Biology of Plants. IK International, Mumbai.

3. Davis P. J. (Eds.).(2004) Plant Hormones.Kluwer Academic Publishers, Dordrecht, Netherlands.
4. Goodwin T.W., Mercer E.I. (1998) Introduction to Biochemistry. CBS Publishers, New Delhi.
5. Heldt H. W. (2004) Plant Biochemistry. Academic Press, California.
6. Lawlor D.W. (2001) Photosynthesis in C3 and C4 Pathway. 3rd Ed. Viva. New Delhi.
7. Nelson David and Cox Michael. (2007) Lehninger Principles of Biochemistry.W.H.Freeman and Company. New York.
8. Lincoln Taiz and Eduardo Zeiger (2010) Plant Physiology, Fifth edition. Sinauer Associates, Inc. Publishers. Sunder land, USA.

BO 1.3 - Genetics and Breeding	4C
Credit- 1	
1. Concept of Gene: Allele, multiple allele, pseudoallele.	1L
2. Extensions of Mendelian principles: Codominance, Incomplete dominance, gene interactions, pleiotropy, genomic imprinting, penetrance, expressivity and phenocopy, sex linkage, sex limited and sex influenced characters	6L
3. Extrachromosomal inheritance: Inheritance of mitochondria and chloroplast genes, maternal inheritance and its effect.	4L
4. Inheritance of complex traits - introduction to complex traits, Polygenic inheritance. Heritability & its measurement	5L
Credit- 2	
1. Phage genetics: Phage mutants, Lytic and lysogenic cycles in phages. genetic recombination, specialized transduction, site specific recombination, mapping the bacteriophage genome, Fine structure analysis of rII gene in T4 bacteriophage.	5L
2. Microbial genetics: Methods of genetic transfers – transformation, conjugation, transduction and sex-duction, mapping genes by interrupted mating,	5L
3. Gene mapping methods: Linkage and crossing over, 3 point test cross and construction of linkage maps, tetrad analysis,	5L
Credit- 3	
1. Karyotype analysis: Method, banding patterns, karyotype evolution, applications	2L
2. Structural alterations of chromosomes: Deletion, duplication, inversion, translocation, complex translocation heterozygotes, Robertsonian translocations, BA translocations and their genetic implications	4L
3. Numerical alterations of chromosomes: Euploidy and aneuploidy and their genetic implications	3L
4. Population genetics: Allele frequencies and genotype frequencies, random mating and Hardy-Weinberg principle, Implications of Hardy-Weinberg principle, rate of change in gene frequency through natural selection, mutation, migration and random genetic drift.	6L
Credit- 4	
1. Plant Genetic resources: Centers of origin and centers of diversity, Importance of genetic diversity in crop improvement and its erosion.	3L
2. Breeding methods in self, cross pollinated and clonally propagated crops: Self pollinated crops: Mass selection, Pureline selection, Pedigree selection, Bulk method, Backcross method	3L
Cross pollinated crops: Mass selection, Progeny selection, Recurrent selection	3L
Clonally propagated crops: Clonal selection, Hybridization	3L
3. Mutation breeding : Types, Mutagens: Physical and chemical mutagens, Mutant types, Role of mutation in breeding.	2L
4. Role of polyploidy in plant breeding	2L

BO 1.4 - (Practicals based on BO 1.1)**6C****Practicals on Algae:****(Any 9 practicals)**

1. Handling of compound microscope and methods to study algae (Use computational facility attached with microscope for observations) **2P**
2. Morphological observations, documentation (description and illustrations) and classification with reasons of taxa belonging to:
 - a. Chlorophyta **3P**
 - b. Charophyta **1P**
 - c. Phaeophyta **1P**
 - d. Rhodophyta **1P**
 - e. Cyanophyta **1P**
 - f. Minor groups **1P**
3. Use of monographs **1P**

Practicals on Fungi:**(Any 9 practicals)**

Study of the representative genera belonging to Myxomycotina, Mastigomycotina, Zygomycotina, Ascomycotina, Basidiomycotina and Deuteromycotina with respect to observations made based on tissue differentiation, accessory organs, asexual and sexual structures, and fruiting body: Ascocarp/Basidiocarp.

- Subdivision Myxomycotina:** Any five forms **1P**
Subdivision Mastigomycotina: Any five forms **1P**
Subdivision Zygomycotina: Any two forms **1P**
Subdivision Ascomycotina: Any ten forms **1P**
Subdivision Basidiomycotina: Any ten forms **1P**
Subdivision Deuteromycotina: Any four forms **1P**

- Lichen: Any three forms** **1P**
Preparation of PDA medium and isolation and culture of plant pathogenic fungi **2P**
Study the antimicrobial activity against of *Trichoderma* against fungi. **2P**

Practical on Bryophytes:**(Any 6 practicals)**

Morphological, anatomical, and reproductive studies of the following members:

1. **Marchantiales:** *Astrella*, *Plagiochasma*, *Targionia* and *Cyathodium*. **1P**
2. **Metzerineae:** *Fossombronia*, *Pallavicinia*, *Riccardia* and *Metzaria* **2P**
3. **Jungermannie:** *Porella*, *Fruillania* **1P**
4. **Anthocerotales:** *Folioceros*, *Phaeoceros*, *Notothylus* **1P**
5. **Musci:** *Sphagnum*, *Polytrichum*, *Pogonetum*, *Bryum*, *Fissidens* **1P**

BO 1.5 - Practicals on BO1.2**3C****Physiology****(Any 12 practicals)**

1. Estimation of soluble proteins in germinating and non-germinating seeds by Lowry / Bradford's method **2P**
2. Estimation of total amino acids in germinating and non germinating seeds **1P**
3. Estimation of ascorbic acid in ripe and unripe fruits **1P**
4. Bioassay of Cytokinin concentration using test system of greening of cotyledons **2P**
5. Studies on induction of amylase activity by GA3 in germinating cereal grains **2P**
6. Measurement of respiration and photosynthetic rates using oxygen electrode (demonstration) **1P**
7. Measurement of CO₂ uptake using IRGA (Demonstration) **1P**
8. Assay of Nitrate reductase activity **2P**
9. Assay of PEPcase activity in a C3 and C4 plant **2P**
10. Assay of invertase activity **2P**
11. Separation of flavonoids using chromatography **2P**

BO 1.6 - Practicals on BO1.3 **3C**

Genetics and breeding **(Any 12 practicals)**

1. Preparation of stains, Fixatives, preservatives and pretreatments to plant material **1P**
2. Karyotype analysis, preparation of somatic C- metaphase chromosomes of appropriate material using camera lucida drawing and Karyotype analysis in Allium/Aloe. **2P**
3. Study of meiotic configuration In maize/ Allium, Rhoe/Aloe, Tradescantia (prophase I, chiasma analysis). **3P**
4. Study of chromosomal aberrations in irradiated plant material **1P**
5. Study of Polygenic inheritance. **1P**
6. Problems of Mendelian inheritance and estimation of gene frequencies and heterozygotic frequencies, population genetics and Linkage. **1P**
7. Neurospora tetrad aanalysis. **1P**
8. Handling of Drosophilla for study of mono, dihybrid, and sex linked inheritance **1P**
9. Linear differentiation of chromosomes through banding techniques such as C-Banding, G-Banding and Q-Banding. **2P**
10. Penetrance and expressivity of PTC testing ability in humans and tongue rollers/non rollers **1P**
11. Floral Biology, study of Pollen Viability, germination in vitro and staining of any two major crops. **1P**
12. Study of monohybrid and dihybrid crosses and interactions. **1P**
13. Study of quality traits in rice, cotton/wheat/soybean/Brassica. **1P**
14. Use of Colchicine for induction of polyploidy in appropriate plant material. **2P**

BO 2.1 - Taxonomy II (Pteridophytes, Gymnosperms)	4C
Pteridophytes	
Credit 1	
Introduction, characteristic features and diversity of Pteridophytes	3L
Migration to land, affinities with Bryophytes, Algae	3L
Recent systems of classification	1L
Study of Fossil groups-	
Psilopsida- salient features of Psilophytes, Rhynia	2L
Lycopsida- salient features of Lepidodendrales	2L
Sphenopsida – salient features of Calamitales <i>Calamites</i> , <i>Annularia</i> , <i>Calamostactys</i> .	2L
Pteridosperms - salient features of pteridosperms <i>Lyginopteris</i> , <i>Oldhamia</i> , <i>Lagenostoma</i> .	2L
Credit 2	
Comparative account of distribution, morphology, anatomy, gametophyte, sporophyte and interrelationships of following orders–	
Psilotales	1L
Lycopodiales	1L
Isoetales	1L
Equisetales	1L
Ophioglossales	1L
Maratiales	1L
Osmundales	1L
Filicales	1L
Marsileaales	1L
Salviniales	1L
Alternation of generations, Apogamy, Apospory.	1L
Telome concept	1L
Stelar evolution	1L
Soral evolution	1L
Gametophyte evolution, Heterospory and seed habit	1L
Gymnosperms	
Credit 3	
Study of fossil groups, Bennetiales, Caytoniales, Glossopteridales. Geographical distribution, characteristic features, affinities with Pteridophytes and Angiosperms.	4L
Classification systems	1L
Distinct features of Progymnosperms, Pteridospermales, Cycadeoidales, Cycadales, Caytoniales, Glossopteridales, Pentoxylales, Ginkgoales	4L
Comparative account of morphology, anatomy, sporogenesis, gametogenesis, embryology and interrelationships of Cycadales, Ginkgoales.	6L

Credit 4

Comparative account of morphology, anatomy, sporogenesis, gametogenesis, embryology, and interrelationships of

Cordiatales	3L
Voltziales	2L
Coniferales	3L
Taxales	2L
Welwitschiales, Ephedrales, Gnetales	3L
Seed development	2L

References:

1. Agashe SN (1995) Paleobotany, Oxford and IBH Publ. Co.Pvt. Ltd., New Delhi.
2. Anold AC (2005 Repr.) An Introduction to Paleobotany, Agrobios (India), Jodhpur.
3. Bhatnagar Sp and Motia A (1996) Gymnosperms. New Age International, New Delhi.
4. Biswas C and Johri BM (1997) Gymnosperms. Narso. Pub., New delhi.
5. Chamberlain CJ (1986) Structure and Evolution. CBS Punlishers, New Delhi
6. Eames EJ (1983) Morphology of Vascular Plants. Standard University Press.
7. Johari M, Sneh Lata and Kavita Tyagi (2012) A textbook of Gymnosperm.Dominant Publishers and Distributors, New delhi.
8. Rashid A (1999) An introduction to Pteridophyta. Vikas Publishing house Pvt.Ltd. New Delhi.
9. Sharma OP (1990) textbook of Pteridophyta. Mac Millan India Ltd. Delhi.
10. Singh VP (2006) Gymnosperms (Naked seed plants): Structure and development, Sarup and sons, New Delhi.
11. Smith GM (1955) Cryptogamic Botany Vol. II Mc Grew Hill.
12. Sporne KR (1986) The morphology of Pteridophytes. Hutchinson University Press. London.
13. Stewart WN and Rothwell GW (2005) Paleobotany and the Evolution of plants, 2nd Edn. Cambridge University Press.
14. Sundara Rajan S. (1999) Introduction to Pteridophyta. New Age International Publishers, New Delhi.
15. Surange KR (1966) Indian fossil Pteridophytes. Council of Scientific and Industrial research.
16. Parihar NS (1976) Biology and morphology of the Pteridophytes. Central Book Depot.

BO 2.2 - Cell Biology **4C**

Credit 1 Cell organelles (I) –functional aspects

1. Cell wall – biogenesis, ultra structure and function. Growth - primary and Secondary wall **3L**
2. Cell membranes: molecular organization, Fluid mosaic model, membrane protein diffusion, electrical properties of membranes, transport across membranes - facilitated diffusion, carrier & channel proteins, transporters, active transport, transport of ions and solutes **4L**
3. Molecular organization of chloroplast and mitochondrial membranes. **3L**
4. Plasmodesmata – Structure and role in movement of molecules, virus transport **2L**
5. Vacuoles – Tonoplast membrane biogenesis, transporters, role as storage organelle, transport across vacuolar membrane **3L**

Credit 2 Cell organelles (II) –functional aspects

1. Endoplasmic reticulum- Role in synthesis and transport of Secretory proteins **2L**
2. Golgi complex – role in sorting , storage and secretion, **2L**
3. Lysosomes, membrane integrity and role Glyoxysomes and Peroxisomes- structure and functions, **2L**
4. Cytoskeleton – composition and organization of microtubules, microfilaments. Treadmilling , role in cell division, signaling and intracellular traffic. Role in motility- flagella- Structure and organization. **4L**
5. Nucleus – Structure, organization and regulation of nuclear pore complex. Transport across nuclear membrane. **2L**
6. Ribosomes – Structure, assembly and dissociation of subunits, function. **2L**
7. Biogenesis of chloroplasts and mitochondria **1L**

Credit 3 Signal transduction

1. Signal transduction: Types of receptors ,G-proteins and G-protein coupled receptors **4L**
2. Phospholipid signaling, Ca⁺⁺-calmodulin cascade, diversity in protein kinases and phosphatases, secondary messengers, regulation of signaling pathways **5L**
3. Specific signaling mechanisms with suitable examples – biotic and abiotic stress, ABA induced stomatal closure, **4L**
4. Nuclear-organelle signaling during plastid development **2L**

Credit 4 Cell cycle, aging and cell death

1. Cell Cycle – Phases of Cell Cycle, functional importance of each phase, Molecular events during cell cycle, Check points, Cyclins and protein kinases, MPF (maturation promoting factor), Regulation of cell cycle. Methods to study cell cycle – labeled mitotic curve, flow cytometry, use of mutants. **8L**
2. Cell aging and cell senescence, programmed cell death- molecular aspects, regulation of cell death, PCD in response to stress **4L**
3. Apoptosis- Role of different genes, cell organelles during apoptosis, genetic control of apoptosis. **3L**

Reference Books:

1. Alberts B., Bray, D., Lewis, J., Raff, M., Roberts, K. and Watson, J. D. 1989. Molecular biology of the Cell (2nd edition). Garland Pub. Inc., New York.
2. Karp, G. 1999. Cells and Molecular Biology: Concepts & Experiments. John Wiley and Sons, Inc., USA.
3. Lodish S, Baltimore B , Berk, C and Lawrence K, 1995 , Molecular Cell Biology , 3rd edn, Scientific American Books, N.Y
4. De Robertis and De Robertis, 1988, Cell and Molecular Biology, 8th edn, Info-Med, Hongkong.
5. Buchanan, Grisse and Jones, 2000, Biochemistry and Molecular Biology of Plants, American Soc. Plant Biologists, Waldorf.
6. Lewin, B. 2000. GENE VII. Oxford University Press, New York, USA
7. Cooper G M and Hausman R E,2007 , The Cell: Molecular Approach 4th Edn, Sinauer Associates,USA.

BO 2.3 - Molecular Biology	4C
Credit – 1 DNA	
1. DNA structure – types of base pairing, unusual structures, topology	2L
2. Melting and reassociation of DNA, Cot curves and kinetic complexity of DNA. Organization of genomes (from whole genome sequences), repetitive and unique sequences, C value paradox, gene duplication and divergence. Number of genes, exons. Rot curves and gene expression	3L
3. Packaging of genomes in viruses, bacteria, organelles and nuclei. Structure of chromatin, nucleosome positioning. Histone modifications. Chromosome organization, centromeres, telomeres, specialized chromosomes	3L
4. Initiation, elongation and termination of DNA replication, molecular machinery of DNA replication in prokaryotes and eukaryotes.	3L
5. DNA damage and repair.	2L
6. Molecular mechanism of recombination and transposition	2L
Credit – 2 RNA	
1. RNA structure – modified bases, pairing, secondary structure	2L
2. Transcription units, RNA polymerases, initiation, elongation and termination of transcription in prokaryotes and eukaryotes, proof reading	5L
3. RNA processing – Processing of tRNA, rRNA and mRNA. mRNA localisation	5L
4. Non-coding RNAs, ribozymes and riboswitches	3L
Credit – 3 Proteins	
1. Protein synthesis – tRNA charging, ribosomal organisation Initiation, elongation and termination of protein synthesis in prokaryotes and eukaryotes. Proof reading	6L
2. Post-transcriptional processing of proteins, Proteases and their role in processing and degradation of proteins	4L
3. Targeting of organelle and secretory proteins. Localisation of membrane proteins. Chaperones and protein folding.	3L
4. Seed-storage proteins and their genes in cereals and legumes.	2L
Credit – 4 Regulation of gene expression	
1. Regulation of transcription - Operons, repressors and inducers, positive and negative control, regulation of lytic and lysogenic cycles in phages.	4L
2. Transcription factors in eukaryotes, response elements. Post-transcriptional regulation.	4L

3. Regulation of gene expression at higher levels of genome organization, chromatin remodeling, locus control regions, enhancers and insulators **4L**
4. Regulation of protein synthesis, post-translational regulation, regulation of protein function **3L**

Reference Books:-

1. Genes VIII- Benjamin Lewin, Oxford University Press Oxford, 1997
2. Genes IX– Benjamin Lewin, Jones and Bartlett, 2008
3. Genes X– Benjamin Lewin, Jones and Bartlett, 2011
4. Molecular Biology of the Cell – Alberts, B, Bray, D, Raff, M, Roberts, K and Watson JD, Garland Publishers, 1999
5. Principles of Biochemistry – Lehninger, W.H. Freeman and Company, 2005

BO 2.4 – Ecology **4C**

Credit 1: The concept and scope of ecology

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|---|----|
| 1. Introduction | 2L |
| 2. Plant interaction with abiotic factors such as climatic, edaphic and Topographic factors | 4L |
| 3. Plant-plant interaction, concept of allelopathy | 2L |
| 4. Plant-animal interaction, herbivory, carnivorous plants | 2L |
| 5. Plant- microbes interaction: Mutualism, parasitism | 2L |
| 6. Ecological modeling | 3L |

Credit 2: Ecosystem ecology

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|---|----|
| 1. Organization of Ecosystem: biotic and abiotic components | 2L |
| 2. Ecosystem types: Terrestrial, aquatic and artificial | 2L |
| 3. Biomes of the world | 4L |
| 4. Biomes of India – Case studies of terrestrial (forest, grassland) and aquatic (fresh water, marine, estuarine) ecosystems. | 5L |
| 5. Island biogeography | 2L |

Credit 3: Population and community ecology

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|---|----|
| 1. Habitat and niche | 2L |
| 2. Characteristics of population: Distribution and size of the population, factors affecting population size. | 3L |
| 3. Ecological limits and the size of population | 1L |
| 4. Life history strategies, r and k selection, C-S-R triangle | 2L |
| 5. Concept of metapopulation, extinction events, population viability analysis | 3L |
| 6. Community structure and species diversity | 2L |
| 7. Diversity types and levels (alpha, beta and gamma), ecotone and edge effect. | 2L |

Credit 4: Ecosystem dynamics

- | | |
|---|----|
| 1. Energy flow models and mineral cycling | 5L |
| 2. Ecosystem productivity- primary and secondary production | 2L |
| 3. Plant succession: seral communities, xeric, aquatic, concept of climax, secondary succession on disturbed land | 6L |
| 4. Resistance and resilience of ecosystem, homeostasis and homeorhesis | 2L |

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17. Odum, E. P. (2007) Fundamentals of ecology, 5th edition, Thomson books.
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Pteridophytes –**(5 Practicals)**

Morphological and/or anatomical and/or reproductive studies of the following members with the help of live material/or herbarium specimens and/or museum specimens and/or permanent slides of the following orders: (any 8 orders - 4P)

1. Psilotales: *Psilotum*, *Tmesipteris*
2. Lycopodiales: *Lycopodium*
3. Selaginellales: *Selaginella*
4. Isoetales: *Isoetes*
5. *Equisetales*: *Equisetum*
6. Ophioglossales: *Ophioglossum*, *Botrychium*, *Helminthostachys*, *Marattiales*, *Angiopteris*
7. Osmundales: *Osmunda*
8. Filicales: *Anemia*, *Lygodium*, *Gleichenia*, *Ceratium*, *Goniopteris*, *Phymotodes*, *Pteris*, *Acrostichum*, *Blechnum*, *Platyserum*, *Pteridium*, *Pleopeltis*, *Cheilanthes*, *Ceratopteris*, *Athyrium*, *Adiantum*.
9. Salviniales: *Salvinia*, *Azolla*
10. Marsileales: *Marsilea*
11. Study of available fossils of Pteridophytes **1P**

Gymnosperms -**(5 Practicals)**

1. Study of available fossils of gymnosperms **1P**
2. Morphological and/or anatomical and/or reproductive studies of the following members with the help of live material/or herbarium specimens and/or museum specimens and/or permanent slides of the following orders: **4P**
 - i) Cycadales- *Cycas*, *Zamia*, *Ceratozamia*, *Encephalartos*
 - ii) *Coniferales*
 - iii) *Taxales*
 - iv) *Ginkgoales*
 - v) *Gnetales*

Practicals based on BO 2.4 –**(10 Practicals)**

1. Study of morphological and anatomical characteristics of plants under stress **2P**
2. Allelopathic analysis of the plants **2P**
3. Finding minimum size of sampling unit for studying specific plant community **1P**
4. Determination of frequency, density, abundance, dominance and IVI of the plant community **1P**
5. Determination of species richness, similarity and diversity indices in different plant communities **2P**
6. Study of polluted water with respect to DO, free CO₂, phosphates and Palmer's Algal Indices **2P**
7. Studying ecotoxicity on plants through seed germination and stomatal index **2P**

BO 2.6 - Practicals on BO 2.2 and BO 2.3 **5C**

Cell Biology - **(10 practicals)**

1. Differential centrifugation for isolation of cell fractions – Nuclear fraction **1P**
2. Isolation of chloroplasts to study: **2P**
 - a. Hill reaction to measure intactness,
 - b. measurement of size of chloroplasts using micrometry and chlorophyll estimation
3. Isolation of mitochondria for **2P**
 - a. Estimation of succinic dehydrogenase activity
 - b. Microscopic observations using MitoTracker Green FM/ MitoTracker Red 580/ Janus green B
4. Isolation of lysosomal fraction and estimation of acid phosphatase activity **1P**
5. Study of electron micrographs of cell organelles **1P**
6. Study of cell cycle using BrdU (demonstration) **1P**
7. Isolation of protoplasts and viability staining to determine % viability. **1P**
8. Study of metaphase nucleus: Localization of euchromatin and heterochromatin. **1P**
9. Cytochemical studies of special cell types- guard cells, senescent cells, bundle sheath cells, meristematic cells, laticiferous cells, glandular cells, pollen grains **2P**
10. Study of induced cell senescence in leaf discs **1P**
11. Study of programmed cell death in plants **1P**
12. Ouchterlony immunodiffusion technique for testing specificity of antigens and antibodies. **1P**
13. To study plasmodesmatal connections in plant cells **1P**
14. Determination of permeability of living cells to acids and bases **1P**

Molecular Biology - **(10 practicals)**

1. Isolation of plasmid DNA and quantification **2P**
2. Electrophoretic separation of plasmid isoforms **1P**
3. Restriction digestion of plasmid DNA, electrophoresis and molecular weight determination of DNA fragments. **2P**
4. Isolation of plant genomic DNA and quantification **2P**
5. Effect of temperature and alkali on absorbance of DNA – hyperchromicity **1P**
6. Separation of seed-storage proteins from leguminous seed and quantitation of each fraction **2P**
7. SDS-PAGE separation of seed storage proteins from legumes. Determination of molecular sizes of the globulin subunits. **3P**

BO 3.1 - Taxonomy III Angiosperms	4C
Credit 1	15L
1. Principles and methods in taxonomy	2L
2. Botanical Nomenclature- Principles, rules, types, valid publication of species	6L
3. Tools of taxonomy: Floras, Monographs, Herbaria, Botanical Survey of India, Botanical Gardens.	3L
4. Morphological features used in classification, identification. Keys	4L
Credit 2	15L
1. Classification systems: Artificial - Linnaeus	2L
2. Natural – Bentham and Hooker, Bessey	8L
3. Phylogenetic – Cronquist, Takhtajan	2L
4. APG systems of classification	3L
Credit 3	15L
Major clades in the APG III system of classification:	
Basal angiosperms	4L
Magnolids	4L
Monocots, Commelinids	7L
Credit 4	15L
Major clades in APG III system of classification:	
Basal eudicots, Ceratophyllales	3L
Core eudicots-	
Asterids - Campanulids, Lamiids	6L
Rosids - Fabids, Malvids	6L

Reference Books:

1. Agashe SN (1995) Paleobotany, Oxford and IBH Publ. Co. Pvt. Ltd, New Delhi.
2. Cook T (1903). The Flora of Presidency of Bombay, Vol. I (Indian Reprint) Bishen Singh, Mahendra Pal Singh, Dehradun.
3. Cronquist A J (1988). Evolution and Classification of Flowering Plants, 2nd edn, N Y Botanical Garden.
4. Davis P H and Heywood V H (1963). Principles of Angiosperm Taxonomy, Oliver and Boyd.
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10. Judd et al. (2007) Plant Systematics – A phylogenetic approach. Sinauer Pub. 3rd edition
11. Kubitzki K (1977). Flowering Plants Evolution and Classification of Higher Categories. Plant Systematics – Evolution Supplement I.
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17. Simpson M. Plant Systematics Academic Press, 2nd edition.
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19. Sivrajan V V (1984). Introduction to Principles of Plant Taxonomy, Oxford and IBH, New Delhi.
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24. Subrahmanyam K. Aquatic angiosperms. BSI. India

BO 3.2 – Development	4C
Credit 1 – Vegetative development	15L
1. Processes basic to plant development	5L
a. Competence, determination, commitment, specification, induction, differentiation, dedifferentiation and redifferentiation.	
b. Morphogenetic gradients, cell fate and cell lineages.	
c. Polarity and symmetry	
d. Juvenility and transition to adult phase	
e. Programmed cell death, aging and senescence.	
2. Vegetative development –	
a. Meristems types and activities of meristems. Organization of shoot and root apical meristems. Regulation of meristem size, lateral organ initiation from root and shoot meristems.	2L
b. Leaf development, plastochron, phyllotaxy, development of trichomes and stomata	2L
c. Vascular elements – differentiation of xylem, phloem	2L
d. Secondary growth – cambium, structure of wood	2L
e. Secretory tissues – Nectaries, laticifers, resin ducts	2L
Credit 2 – Reproductive development	15L
1. Transition from vegetative to reproductive phase – morphological and histochemical changes in shoot apex, floral meristems and floral development	3L
2. Development of stamen, anther, sporogenous tissue, tapetum, microsporogenesis, pollen and male gametophyte.	2L
3. Development of carpel, ovule, placenta, sporogenous tissue, integuments, megasporogenesis, female gametophyte	2L
4. Interaction between pollen and pistil, pollen tube guidance, self-incompatibility, double fertilization and triple fusion, role of synergids, endosperm development	3L
5. Stages of embryogenesis, structure and organization of embryo, suspensor, fruit development, structure of seed, germination	3L
6. Apomixis - apospory, diplospory and adventive embryony, autonomous and pseudogamous endosperm development	1L
7. Androgenesis and gynogenesis <i>in vitro</i>	1L
Credit 3 –Molecular genetics of plant development	15L
1. Molecular genetics of :	
a. Embryogenesis mutants, establishment of body plan	2L
b. Root, shoot and leaf development	4L
c. Transition to flowering and flower development-ABCE Model	3L
d. Male and female gametophyte development	2L
e. Fertilization, imprinting and endosperm development	2L
f. Fruit and seed development, germination	2L

Credit 4 - Intrinsic and extrinsic factors regulating plant development	15L
1. Light mediated regulation–	
a. Photoreceptors- phytochromes, cryptochromes, phototropins	2L
b. Signal transduction leading to photomorphogenesis and photoperiodic responses	3L
c. Circadian rhythms	2L
2. Hormonal regulation-	
a. Perception, signaling and regulation of gene expression by hormones – Hormone receptors, mutants in hormone signaling, transcription factors involved in hormone signaling	4L
b. Role of hormones in germination, growth and flowering. Cross-talk between hormone signaling pathways	3L
3. Regulation of development by metabolites (sugars, nitrogen status)	1L

References:-

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2. Bhojwani S.S. and Soh W.Y. (2001). Current Trends in Embryology of Angiosperms
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7. Blackwell Scientific Publications
8. Jermy Burgess (1985) An Introduction to Plant Cell Development. Cambridge University Press
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13. Raghavan V. (2000) Developmental Biology of Flowering Plants.Springer Verlag.
14. Razdan M.K. (2003) Plant Tissue Culture, Oxford IBH.

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16. Wada M., Shimazaki K., Iino M. (2005). Light sensing in plants. Springer.
17. Davies P. J. (2004) Plant hormones. Kluwer.
18. Buchanan B. B., Gruissem W. and Jones R. L. (2000) Biochemistry and Molecular Biology of Plants. American Society of Plant Physiology, Maryland

BO 3.3 – Tools and Techniques	4C
Credit 1	
SI System of measurement: Fundamental and derived units.	1L
Making solutions: Moles and molarity, stock solutions and dilutions, making media and reaction mixtures, pH measurements and preparation of buffers	2L
Enzymology: Classification and properties of enzymes, coupled reactions, units of enzyme activity. Enzyme kinetics – substrate concentration and rate ; Km. Competitive and noncompetitive inhibitors. Covalent and allosteric regulation. Coenzymes, Isoenzymes and co-factors	6L
Radioactive techniques: Isotopes and their half-life, Specific activity of radioisotopes, making radioisotope solutions, detection and measurement of radioactivity - radiation counters, liquid scintillation counters, autoradiography.	3L
Microtomy: Principle of tissue fixation for microtomy, types of microtome, serial sectioning and staining.	3L
Credit 2	
Microscopy and microscopic techniques: Light, phase contrast, fluorescence, electron, confocal microscopy. Micrometry. Flow cytometry.	8L
Spectroscopic techniques: Visible, UV, IR spectrophotometry, spectrofluorimetry, NMR and ESR spectroscopy, circular dichroism, atomic absorption and mass spectrometry.	7L
Credit 3	
Chromatographic techniques: Paper, thin layer and column chromatography, gel filtration, ion exchange and affinity chromatography, high pressure liquid chromatography, gas chromatography.	8L
Electrophoretic techniques: Supports, elctoendoosmosis, electrophoresis under native, dissociating and denaturing conditions, isoelectric focusing, staining, activity staining. 2-D electrophoresis, MALDI-TOF	7L
Credit 4	
Immunological techniques: Immune response. Antibodies and their specificity, antigen-antibody interactions, immunodiffusion and immunoelectrophoresis techniques, immunoassays, westernblotting	5L
Centrifugation techniques: High speed centrifuges, rotors, ultracentrifugation, density gradient centrifugation.	3L
Electrochemical techniques: Construction and working of equipments for measurement of electrical conductivity, pH meter.	3L

Measurement of water potential and osmolarity: Osmolarity equation, Osmolarity and osmotic pressure measurement, types of osmometers. Construction and working of osmometers. Measurement of water potential. Pressure chamber for water potential measurement. **2L**

Gas exchange measurements: Types, Construction and working of Infra red gas analyzer, O₂ electrode. **2L**

References:

1. David L. Nelson, Michael M. Cox Lehninger Principles of Biochemistry; W. H. Freeman 6th edition edition 2013.
2. David M Freifelder Physical Biochemistry: Applications to Biochemistry and Molecular Biology (Life Sciences/Biochemistry, W. H. Freeman; 2nd Revised edition, 1983.
3. Jeremy M. Berg, John L. Tymoczko, Lubert Stryer Biochemistry, W. H. Freeman; 7th edition edition 2011.
4. Keith Wilson, John Walker, "Practical Biochemistry Principles and Techniques" Cambridge University Press 2010.
5. S. M. Khasim, "Botanical Microtechnique: Principles and Practice". Capital Publishing Company. 2002.
6. Thomas J. Kindt, Barbara A. Osborne and Richard Goldsby "Kuby Immunology ".W. H. Freeman; 6th edition edition 2006.

BO 3.4a – Pharmacognosy – I**4C****Credit I: Natural products chemistry****15L**

- a. Brief outline and Classification of secondary metabolites,
- b. Major secondary metabolism pathways in plants
- c. Brief outline of occurrence, distribution and synthesis of phenolics, alkaloids, terpenoids, coumarins, flavonoids, glycosides, volatile oils, tannins and resins.
- d. Regulation of secondary metabolite pathways and compartmentation of these in plants
- e. Analysis of metabolic pathways using Bioinformatics tools

Credit II: Analytical tools in Pharmacognosy for separation and identification of natural products**15L**

- a. Application of chromatographic techniques in separation and identification of natural products. Principles of separation and application of Column, Paper, Thin Layer chromatography
- b. Applications of Gas chromatography, HPLC, HPTLC: Preparative and Reverse phase columns, Mobile phase selection and detectors in HPLC, HPTLC and GC.
- c. Mass spectrometry: Basic principles and importance of the technique in pharmacognosy. GC-MS and other recent advances in mass spectrometry.
- d. Interpretation of data for UV, IR, NMR, ¹H NMR, ¹³C NMR & Mass spectroscopy for purification and structural elucidation of phytoconstituents.
- e. Herbal fingerprint profile of single and multicomponent herbal drugs.
- f. Stability testing of natural products. Examples of use of these techniques for plant products

Credit III: Evaluation of drug, processing and marketing**15L**

- a. Evaluation of Drugs: Concept, considerations, parameters and methods of quality control for medicinal plant materials as per various pharmacopoeia and other guidelines.
- b. Preparation of monograph of crude drug.
- c. Comparative study of IP, European Pharmacopoeia, BP / Ayurvedic Pharmacopoeia of India
- d. Pharmacognostic studies of some drugs: w.r.t. Geographical distribution, cultivation, collection, macroscopic and microscopic characters, commercial products if any, chemical constituents, chemical tests, therapeutic uses, commercial varieties, adulterants and substitutes.

Root Drugs	: <i>Aconitum napellus</i> Linn., <i>Gentiana lutea</i> Linn.
Rhizome Drugs	: <i>Rauwolfia serpentina</i> Benth., <i>Acorus calamus</i> Linn.
Stem Drugs	: <i>Ephedra</i> sps. , <i>Quassia amara</i> Linn.
Bark Drugs	: <i>Cinchona</i> sps. , <i>Saraca asoka</i> (Roxb.) De Wild.
Leaf Drugs	: <i>Ocimum sanctum</i> Linn. , <i>Adhatoda vasica</i> Nees.
Flower Drugs	: <i>Woodfordia floribunda</i> Salisb., <i>Eugenia caryophyllata</i> Thumb.
Fruit Drug	: <i>Tamarindus indica</i> Linn. , <i>Corriandrum sativum</i> Linn.
Seed Drugs	: <i>Strychnos nux-vomica</i> Linn. , <i>Plantago ovata</i> Forskal)

Credit IV: Applied Pharmacognosy**15L**

- a. Ethnobotany : Concept, relevance and classification.
Methods and techniques used in ethnobotany.
Ethnopharmacology and its applications,
- b. Nutraceuticals and cosmaceuticals: General introduction, Classification and their formulations, Botanical sources, properties and uses
- c. Regulatory requirements for new drugs: Markers constituents- Definition, importance in crude drug standardization. Examples of Biomarkers.
- d. Standardization, quality, efficacy and safety requirements & assessment procedures for herbal medicines as per USFDA

References :-

1. Smith, P. M. (1976) Chemotaxonomy Of Plants. Publ. Edward Arnold, UK
2. Swain, T. E., 1966, Chemical Plant Taxonomy, Academic Press, London and New York.
3. Tayler, V.E.; Brady, L.R. and Robber, J. R. 1976, Pharmacognosy, Balliere Tindall, Calcutta.
4. Trease and Evans, 1972, Pharmacognosy, Lea and Fobiger, Philadelphia.
5. Wagner, H. 1984, Plant Drug Analysis.
6. Wagner, H., 1977, New Natural Products and Plant Drugs with Pharmacological, Biological or Therapeutical Acitivity.
7. Wallis, T. E., 1967, Practical Pharmacology.
8. Wallis, T.E. 1967 Textbook of Pharmacognosy, J and A Churchill LTD, London.
9. Dewick Paul M. 1998 Medicinal natural products (a biosynthetic approach), Ist edn, by, John Wiley and sons Ltd., England
10. Pushpangadam P., Nyman UIF., George V, 1995, Glimpses of Indian Ethanopharmacology Tropical botanic Gardon and research institute.
11. Peter B. Kaufman 1998 Natural Products from plants, Ist edn, by, CRC press, Newyork,
12. Farooqui A . A. and Shreeramu B.S. 2001 Cultivation of medicinal and aromatic crops, 1st edn, University press, new Delhi
13. Schirmer, R.E., 2000, Modern Methods of Pharmaceutical Analysis, Vol. 1, 2, Boca Raton F.L: CRC Press
14. Indian Pharmacopoeia 2007.
15. European Pharmacopoeia 6th Edn. 2008.

16. Ramavat, K. G., 2003, Plant Biotechnology, S. Chand And Co. Ltd..
17. Greene JJ and Rao VS, 1998.Recombinant DNA – Principles and Methodologies. Marcel Dekker, New York,
18. Primrose SB, Twyman 2001. RM Principles of gene manipulation. and Old RW, 6th Edition, Blackwell Science, Oxford,
19. Collins GB and Shepherd RJ Eds. 1996 Engineering plants for commercial products and applications. NY Acad. Of Science Publishers
20. Senson CW ed. 2002.Essentials of Genomics and Bioinformatics, Wiley-VCH Publishers, NY,
21. Morris, A.H. et al., Eds 1986. Secondary Metabolism in Plant Cell Cultures, Cambridge Univ. Press, Cambridge, U.K.
22. Staba, E.J., Ed. 1980 Plant Tissue Culture as a Source of Biochemicals, C.R.C. Press. Boca Raton, Florida.
23. Kurz W.G.W., Ed. 1989, Primary and Secondary Metabolism of Plant and Cell Cultures, Springer Verlag, Berlin.
24. Bajaj, Y.P.S., Ed. (1988) Biotechnology in Agriculture and Forestry – vol. 4., Springer-Verlag, Berlin, Heidelberg, New York, Tokyo.
25. Vasil I.K. edt (1986) Cell culture and somatic cell genetics of plants Vol. 4., Academic Press, N.Y.
26. Charlwood B.V. and Rhodes MV. Edt (1999), Secondary products from plant tissue culture. Clarendon Press, Oxford.
27. Dicosmo F and Misawa M, Edt (1996), Plant cell culture: Secondary metabolism towards industrial application, CRC press, Boca Raton, N.Y.
28. Ramawat K G and Merillon J M, Edt. (1999) Biotechnology: Secondary metabolites, Oxford IBH Publishing Co., New Delhi
29. Buchanan BB, Grussem W and Jones RL (2000) Biochemistry and molecular biology of plants, IK International Pvt Ltd. New Delhi
30. Verapoorte r and Alferman HW (eds), 2003 Metabolic engineering of plant secondary metabolites. Kluwar Academic Publ., Netherlands

BO 3.4b - Ecophysiology –I **4C**

Credit 1: Water relations and mineral nutrition **(15 lectures)**

1. Plant responses to the environment – Stress responses, Acclimation, Adaptation **1L**
2. Properties and water availability in soil. Soil - Plant - Air continuum. Forces involved in water uptake and transpiration. Hydraulic conductance, Aquaporins **4L**
3. Availability, absorption, transport and assimilation of ions. Ion transport. Low and high affinity transporters. Energising transporters, role of ATPases and PPases. Potassium, Calcium, Magnesium, Iron, Zinc, Copper, Sulphur **4L**
4. Regulation of nitrogen and phosphate uptake. Symbiotic associations to improve availability of nitrogen and phosphorus and the mechanism involved **4L**
5. Chemical and biofertilizers **2L**

Credit 2: Photosynthesis **(15 lectures)**

1. Chlorophyll fluorescence kinetics and determination of PSI, PSII efficiency. Photosynthesis measurements. Light saturation curves, CO₂ response curves and CO₂ compensation point. Canopy photosynthesis, Carbon sequestration by plants **4L**
2. Photoinhibition and protection mechanisms. Water-water cycle, photorespiration **3L**
3. Evolution and diversity of photosynthetic systems. Bacterial photosynthesis, Algal photosynthesis **3L**
4. Regulation of photosynthesis in response to changing climate conditions **2L**
5. Partitioning of photosynthetic assimilates, long distance transport, phloem loading and unloading and its regulation, feedback regulation of photosynthesis. **3L**

Credit 3: Respiration **(15 lectures)**

1. Glycolysis and alternative pathways in plants, regulation **2L**
2. TCA cycle and alternative pathways in plants, GABA shunt **2L**
3. Mitochondrial electron transport system, measurements, inhibitors and uncouplers, Oxidative phosphorylation and respiratory control. **3L**
4. Diverse electron transport systems in plant mitochondria, heat production and energy overflow during alternative electron transport pathway, regulation of alternative oxidase pathway **3L**
5. Interdependence of mitochondria and chloroplasts. Protective effects of mitochondrial respiration on photosynthesis **3L**
6. Growth and maintenance respiration. Role of respiration in plant carbon balance **2L**

Credit 4- Crop physiology (15 lectures)

1. Crop growth - Relative growth rate, Leaf area index and net assimilation rate 4L
2. Allocation of resources to storage organs, fruits and seeds (endosperm, cotyledons)
Source – sink relations. Harvest Index 4L
3. Crop growth and productivity. Factors affecting phenology and yield 3L
4. Water use efficiency and nitrogen use efficiency of crop plants 4L

References : -

1. Berg J.M., Tymoczko J.L., Stryer L. (2002) Biochemistry. 5th Ed. Wlt. Freeman and Company, New York.
2. Buchanan B.B., Grissem W., Jones R.L. (2000) Biochemistry and Molecular Biology of Plants. IK International, Mumbai.
3. Callot W.H., Elliot D.C. (1997) Biochemistry and Molecular Biology. Oxford University press, New York.
4. Davis P. J. (Eds.).(2004) Plant Hormones.Kluwer Academic Publishers, Dordrecht, Netherlands.
5. Goodwin T.W., Mercer E.I. (1998) Introduction to Biochemistry. CBS Publishers, New Delhi.
6. Heldt H. W. (2004) Plant Biochemistry. Academic Press, California.
7. Lawlor D.W. (2001) Photosynthesis in C3 and C4 Pathway. 3rd Ed. Viva. New Delhi.
8. Nelson David and Cox Michael. (2007) Lehninger Principles of Biochemistry.W.H.Freeman and Company. New York.
9. Lincoln Taiz and Eduardo Zeiger (2010) Plant Physiology, Fifth edition. Sinauer Associates, Inc. Publishers. Sunder land, USA.
10. Lamberts

Periodicals and Journals

1. Trends in Plant Sciences
2. Annual Review of Plant Biology
3. Plant Cell
4. Plant Physiology
5. Journal of Plant Physiology
6. Physiologia Plantarum
7. Physiology and Molecular Biology of Plants

BO 3.4c - Plant Biotechnology- I **4C**

Credit 1: Plant tissue culture

1. Totipotency of plant cells and regeneration of plants from differentiated tissues. Molecular events during de- and re-differentiation. Organogenesis and somatic embryogenesis **4L**
2. Micropropagation - Multiplication of plants from pre-existing meristems Stages of micropropagation, Factors affecting micropropagation, case studies in plants of economic importance – trees, crop species, medicinal plants **5L**
3. Hardening of micropropagated plants and field transfer **1L**
4. Secondary metabolite production using plant tissue culture. Bioreactors **5L**

Credit 2: Recombinant DNA technology and gene cloning

1. Introduction to recombinant DNA technology **1L**
2. Enzymes used in genetic engineering- Restriction endonucleases, other endonucleases, exonucleases, ligases, polymerases, kinases and phosphatases, DNA methylases, topoisomerases **4L**
3. Use of vectors in cloning- Plasmids, phages, cosmids, phagemids, BACs and YACs, Gateway system of cloning **6L**
4. Polymerase chain reaction- Principles and uses in gene cloning **4L**

Credit 3: Gene libraries, screening of recombinants and sequencing

1. Genomic and cDNA libraries – choice of vectors, construction **4L**
2. Screening of libraries and isolation of specific genes- Nucleic acid hybridization using specific nucleotide probes, antibodies, PCR amplification using gene specific primers. **5L**
3. DNA sequencing methods, sequencing strategies for large regions of DNA, contig maps, chromosome walking. **2L**
4. High throughput and next generation sequencing methods. **4L**

Credit 4: Genetic transformation of plants

1. Agrobacterium: Ti and Ri plasmids, transfer of DNA into host by *Agrobacterium*, mechanism of integration of DNA into plant genomes **4L**
2. Vectors for plant transformation: Agrobacterium-based vectors, improved Agrobacterium-based vectors, virus-based vectors for transient expression, vectors for chloroplast transformation, vectors for marker-free selection **5L**
3. Transformation techniques: Agrobacterium-mediated, direct DNA transfer. Factors affecting transformation. *In planta* transformation **3L**
4. Screening and analysis of transformants in subsequent generations – copy number, heterozygosity, stable expression, silencing **3L**

References:

1. Recombinant DNA – Principles and Methodologies. Greene JJ and Rao VS, Marcel Dekker, New York, 1998.
2. Principles of gene manipulation. Primrose SB, Twyman RM and Old RW, 6th Edition, Blackwell Science, Oxford, 2001
3. Differentially expressed gene in plants. Hansen and Harper, Taylor and Francis Ltd. London, 1997.
4. Engineering plants for commercial products and applications. Eds. Collins GB and Shepherd RJ, NY Acad. Of Science Publishers 1996
5. DNA markers. Eds. Caetano-Anolles and Gresshoff, Wiley-VCH Publishers, NY, 1998
6. Introduction to Bioinformatics. Attwood, T.K., Parry-Smith, DJ, Addison Wesley Longman, Harlow, Essex, 1999
7. Bioinformatics. Westhead, DR, Parish JH and Twyman, RM, BIOS Scientific Publishers Ltd., Oxford, 2003
8. Bioinformatics – Sequence and genome analysis. D.W. Mount, CBS Publishers, NewDelhi, 2003
9. Collins GB and Shepherd RJ Eds., 1996, Engineering plants for commercial products and application. , NY Acad. Of Science Publishers
10. Senson CW Edt, 2002, Essentials of Genomics and Bioinformatics,. Wiley-VCH Publishers, NY,
11. Charlwood B.V. and Rhodes MV Edt. 1999, Secondary products from plant tissue culture. Clarendon Press, Oxford.
12. Dicosmo F and Misawa M, Edt 1996, Plant cell culture: Secondary metabolism towards industrial application, CRC press, Boca Raton ,N.Y.
13. Ramawat K G and Merillon J M, Edt.,1999 Biotechnology: Secondary metabolites, Oxford IBH Publishing Co., New Delhi
14. Buchanan BB, Grussem Wand Jones RL ,2000 , Biochemistry and molecular biology of plants , IK International Pvt Ltd. New Delhi
15. Verapoorte R and Alferman HW Eds ,2002 Metabolic engineering of plant secondary metabolites. Kluwar Academic Publ., Netherlands

Relevant review articles from journals

BO 3.4d - Biodiversity and Bioprospecting - Algae, Fungi – I **4C**

Credit: 1

1. Tools in algal systematics. **1L**
2. Systematics of Blue green algae: Botanical and Bacteriological approaches, Komarek's contribution, Chemotaxonomic studies, phylogeny and evolution. **3L**
3. Systematics of Green algae: Morphological concept, Ultrastructural concept: Flagella, flagellate cell architecture, cell wall, chloroplast, pyrenoids, eye spots; Mitosis and cytokinesis, Karyology, Green algal phylogeny and evolution. **4L**
4. Systematics of Brown algae: Classical classification, Environmental factors in life histories and ultrastructural studies, Molecular systematics, Phylogeny and evolution. **2L**
5. Systematics of Red algae: Development of primary and secondary pit connections, Ultrastructure of pit plugs, meiotic studies, structural and molecular evidences for red algal relationships. **2L**
6. Systematics and molecular phylogeny of Xanthophyceae, Eustigmatophyceae, Bacillariophyceae, Dinophyceae and Euglenophyceae. **3L**

Credit: 2

1. Algal habitats, ecological classification of algae. **2L**
2. Algae in Marine environments: Marine environment in general, distribution of algae, Intertidal seaweeds, zonation patterns, factors affecting distribution of marine algae in intertidal region. **3L**
3. Limnology: Introduction, Physicochemical features, algae in aquatic food chains, biogeochemical cycles, Phytoplanktons, adaptations, Periodicity, Succession. **5L**
4. Algae in extreme environments and survival strategies. **2L**
5. Factors causing algal blooms, effects of algal blooms, bloom control; biofouling, carbon sequestration, algae bioindicators. **3L**

Credit: 3

1. Systematics, origin, evolution and phylogeny of fungi: Natural and molecular method of fungal systematics. **3L**
2. Fungal systematics: Kingdom fungi - Microsporidia, Chytridiomycota, Neocallimastigomycota, Blastocladiomycota, Zoopagomycotina, Kickxellomycotina, Entomophthoromycotina, Mucoromycotina, Glomeromycota. **12L**

Credit: 4

1. Fungal systematic: Kingdom fungi: Subkingdom - Dikarya: Ascomycota, Basidiomycota. **8L**
2. Ecosystem mycology: 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. **5L**
3. Biodiversity and bioprospecting of Basidiomycetes of Western ghats **2L**

References: Biodiversity and Bioprospecting of algae

1. Barsanti, L. and Gualtieri, P. (2006). *Algae: structure, anatomy, biochemistry and biotechnology*. Taylor & Francis, pp. 301.
2. Bellinger, E. G. and Sigeo, D. C. (2010). *Freshwater algae: Identification and use as a bioindicators*. Wiley-Blackwell NJ, pp. 271.
3. Brodie, J. and Lewis, J. (2007). (Ed.) *Unravelling the algae: the past, present and future of algal systematics*. CRC Press, New York, pp. 335.
4. Bryant, D. A. (1994). (Ed.) *The molecular biology of Cyanobacteria*. Kluwer Academic Publishers, The Netherlands, pp. 881.
5. Dawson, E. Y. (1966). *Marine botany*. Holt, Rinehart and Winston, Inc., pp. 371.
6. Grahm, L. E. and Wilcox, L. W. (2000). *Algae*. Prentice-Hall, Inc., NJ, pp. 640.
7. Hallmann, A. (2007). Algal transgenics and biotechnology. *Transgenic Plant Journal*, Vol: 1(1), 81-98.
8. Kaushik, B. D. (1987). *Laboratory methods for blue green algae*. Associated Publishing Company, New Delhi, pp. 171.
9. Khattar, J. I. S., Singh, D. P. and Kaur, G. (2009). (Ed.) *Algal biology and biotechnology*. I. K. International Publishing House Pvt. Ltd., pp. 266.
10. Kumar, H. D. (1999). *Introductory Phycology* (2nd Ed.). Affiliated East-West Press Pvt. Ltd., New Delhi, pp. 651.
11. Lee, R. E. (1999). *Phycology*. Cambridge University Press, pp. 614.
12. Lobban, C. S. and Harrison, P. J. (1994). *Seaweed ecology and physiology*. Cambridge University Press, 367.
13. Round, F. E. (1984). *Ecology of algae*. Cambridge University Press, pp. 664.
14. Lobban, C. S. and Wynne, M. J. (1981). (Ed.) *The biology of seaweeds (Botanical monographs: volume-17)*. Blackwell Scientific Publications, pp. 786.
15. Seckbach, K. (2007). (ed.) *Algae and cyanobacterial in extreme environment*. Springer, The Netherlands, pp. 811.
16. Van Den Hoek, C., Mann, D. G. and Jahns, H. M. (1995). *Algae: An introduction to phycology*. Cambridge University Press, pp. 625.

References: Biodiversity and Bioprospecting of Fungi

1. Hibbett DS, Binder M, Bischoff JF, Blackwell M, Cannon PF, Eriksson OE, *et al.* (2007). "A higher level phylogenetic classification of the *Fungi*" (PDF). *Mycological Research* 111 (5): 509–547. doi:10.1016/j.mycres.2007.03.004. PMID 17572334.
2. 21century guidebook of fungi, David Moore, Geoffrey D. Robson, Anthony P. J. Trinci:Cambridge university press. 2011
3. Introduction of Fungi by John Webster and Roland Weber, Third edition, Cambridge University Press, 2007.
4. Introductory Mycology by Alexopolous J., Mims C. W. and M. Blackwell, fourth edition, Wiley India Pvt Ltd, 2007.
5. Topics in Mycology and Pathology by L. N. Nair, first edition, New Central Book Agency Kolkata, 2007.
6. Fungal Biology by J. W. Deacon, forth edition, Blackwell Publishing Ltd, 2006.
7. Biodiversity of fungi: Inventory and Monitoring methods by M. S. Foster, G. F. Wills and J. M. Mueller, first edition, Academic Press, 2004.
8. Mycoremediation: Fungal Bioremediation by Harbhajan Singh, first edition, John Wiley and Sons, Hoboken, New Jersey, 2006.

BO 3.4e - Biodiversity and Bioprospecting - Angiosperms – I	4C
Credit 1	
1. Darwin, Origin of species, Neodarwinism	4L
2. Systematics: overview, sources of data for systematics: Morphology, Anatomy, Embryology, Palynology, Biochemistry, Micromorphology, Karyology, protein and DNA sequences	8L
3. Species concept and categories	3L
Credit 2	
1. Origin of angiosperms – land plants, vascular plants, seed plants	3L
2. Continental drift and evolution of angiosperms- fossil angiosperms, evolutionary trends	3L
3. Evolution of vessels, sieve elements, leaf	3L
4. Evolution of flower, carpel, male and female gametophytes, seed	6L
Credit 3	
1. Species diversity: Species Richness, Species Abundance. Spatial Patterns of Species Diversity, Endemism	8L
2. Origin and diversity of crops: Domestication and cultivation, Dispersal and Diversification. Centres of Diversity	6L
3. Threats to biodiversity	1L
Credit 4	
1. DNA based markers - DNA polymorphism studies using hybridization-based techniques and PCR based techniques – RAPD, AFLP, SSR polymorphisms, microsatellite-primed PCR, Sequence-based polymorphism	6L
2. Determining genetic relatedness using DNA based markers – Clustering and Dendrogram construction using Distance based methods, UPGMA, Neighbour joining. Character based methods - Maximum likelihood, maximum parsimony	4L
3. Applications of molecular markers Diversity studies, DNA fingerprinting, Population structure, Phylogenetic relationships, Taxonomic disputes	5L

Reference Books:

1. Krishnamurthy K.V. (2003) An Advanced Textbook on Biodiversity-Principles and Practice, Oxford & IBH Publ. New Delhi
2. Handbook of the Convention on Biological Diversity (2001), Secretariat of the Convention on Biological Diversity. Earthscan publ., London
3. Biodiversity and Conservation (2005), Michael J. Jeffries, Routledge, London
4. Handbook of Biodiversity Methods – Survey, Evaluation and Monitoring (2004) Edt.- David Hill, Matthew Fasham, Graham Tucker, Michael Shewry & Philip Shaw; Cambridge
5. This Fissured Land: An Ecological History of India (1992) Gadgil M. & Guha R.; Oxford University Press, New Delhi
7. Restoration of Endangered Species (1996) ed- Bowles M.L. & Whelan C.J.; Cambridge Univ. Press.
8. Preservation and Valuation of Biological Resources (1990); Orians GH, Brown GM, Kunin WE & Swierbinski JE.; Univ. Washington Press
9. Paradise Lost? The Ecological Economics of Biodiversity (1994); Barbier EB, Burgess JC & Folke C.; Earthscan, London
10. Molecular Markers, Natural History and Evolution (1994), Avise JC; Chapman & Hall, London
11. Forest Genetic Resources: Status, Threats and Conservation Strategies (2001), Uma Shaanker, R.Ganeshiah, KN. & Bawa KS (Eds); Oxford & IBH, New Delhi
12. Global Biodiversity Strategy: Guidelines for Action to Save, Study, and Use Earth's Biotic Wealth Sustainably and Equitably (1992) WRI/IUCN/UNEP; WRI Publ, Baltimore, MD.
13. Plant Diversity Hotspots in India – An Overview (1997) Edt.- Hajra P.K. & V. Mudgal, BSI
14. The Economics of Biodiversity Conservation (2007), K.N. Ninan, Earthscan, London
15. Plant Systematics, Simpson M. Academic Press, 2nd edition.
16. Plant Systematics – Judd et al. (2007) A phylogenetic approach. Sinauer Pub. 3rd edition.

BO 3.5 - Practicals on BO 3.1 and BO 3.2**4C****Practicals on BO 3.1 – Taxonomy of Angiosperms****8P**

1. Studies on the following Classes as per Bentham and Hooker system using any 3 type specimen and preparation of artificial keys for identification of any two unknown specimen:

Dicotyledonae

- a. Polypetalae - Thalamiflorae, Disciflorae, Calyciflorae
- b. Gamopetalae – Inferae, Heteromerae, bicarpellatae
- c. Monochlamydae – Curvembryae, Multiovulate aquaticae, Multiovulate terrestris, Microembryae, Daphniales, Achlamydosporae, Unisexuales, Ordina anamoli

Monocotyledonae

- a. Microspermae
- b. Epigynae
- c. Coronariae
- d. Calycinae
- e. Nudiflorae
- f. Apocarrae
- g. Glumaceae

Practicals on BO 3.2 – Development**8P**

1. Isolation of vegetative and reproductive apical meristems **1P**
2. Tracing the course of stomatal development and observations on stomatal types. **1P**
3. Anatomical studies on secondary growth (wood) **1P**
4. Origin and development of epidermal structures (trichomes, glands and lenticels) and study of secretory structures (nectaries and laticifers). **1P**
5. Histochemical comparison between vegetative SA and reproductively induced SA **1P**
6. Observations on **4P**
 - a. Microsporogenesis and development of male gametophyte (pollen)
 - b. Megasporogenesis and development of female gametophyte
7. Observations on types of endosperm, dissection and isolation of endosperm **1P**
8. Observations on stages of embryo development, dissection and isolation of developing embryo (3 stages) **1P**
9. *In vitro* germination of spore/pollen, Correlation between fertility (stainability), viability (TTC and FDA staining) and germinability (*in vitro*) of pollen grains. **1P**

BO 3.6 - Practicals on BO 3.3	3C
Practicals:	12P
1. Preparation of solutions of different concentrations. Conductivity and pH measurements. Determination of pKa values and buffering capacity of acetate buffers	2P
2. Absorption spectra of BSA / DNA and determination of absorption maxima, molar extinction coefficient	1P
3. Separation of Plant Pigments by Thin Layer Chromatography and Column Chromatography.	2P
4. Demonstration of HPLC and HPTLC techniques and quantification.	2P
5. Separation of protein Gel filtration/ affinity / ion exchange chromatography	2P
6. Ouchterlony immunodiffusion technique for testing specificity of antigens and antibodies.	2P
7. Demonstration of Spectrofluorimetry	1P
8. Microtomy – fixation, dehydration, serial sectioning and staining of plant tissues	4P
9. Effect of pH, temperature, concentration of enzyme on invertase activity	2P
10. Effect of substrate concentration on invertase activity.	1P
11. Native PAGE and activity staining.	2P

BO 3.7a - Practicals on Pharmacognosy –I**3C****(Any 12 practicals)**

1. Identification of drug with the help macroscopic & microscopic evaluation techniques, Percentage extractives and fluorescence analysis of drugs **1P**
2. Histochemical studies of drugs and determination of ash values of drugs. **1P**
3. Chemotaxonomic studies of drugs belonging Meliaceae, Rutaceae and Simarubiaceae **1P**
4. Estimation of alkaloids from suitable medicinal plants. **1P**
5. Estimation of glycosides from suitable medicinal plants. **1P**
6. Extraction of essential oils from suitable medicinal plants. **1P**
7. Thin layer chromatography and identification of phytoconstituents using standard compounds **1P**
8. Paper chromatography and identification of phytoconstituents using standard compounds **1P**
9. Characterization of the phytopharmaceuticals by HPLC / HPTLC **2P**
10. Profiling of plant extracts using HPTLC as a marker for identification **2P**

BO 3.7b - Practicals on Ecophysiology - I

3C

(Any 12 practicals)

1. Study of transpiration and stomatal physiology under abiotic stress using IRGA **2P**
2. Determination of rate of photosynthesis using IRGA **2P**
3. Measurement of chlorophyll fluorescence and calculating Fv/Fm ratios. **2P**
4. Determining respiration flux through cytochrome c and AOX pathway using oxygen electrode **2P**
5. Determining Rubisco and PEPcase activities in C3 and C4 plants **2P**
6. Comparison of alteration in growth rate, days to flowering, in any one crop plant subjected to altered photoperiod / excess nitrogen fertilizer / water deficiency **3P**
7. Estimation of neutral and acid invertase activity during grain filling in any crop sp. **3P**

BO 3.7c - Practicals on Plant Biotechnology-I

3C

(Any 12 Practicals)

1. Construction of recombinant plasmid using REs, PCR based methods **3P**
2. Transformation of *E.coli* with recombinant plasmid, selection of transformants by Selectable markers / blue- white screening. **3P**
3. Transformation of *A. tumefaciens* with binary vector using freeze thaw method and selection for transformants. **2P**
4. Micropropagation of plants using organogenesis / somatic embryogenesis **3P**
5. Manipulation of cell cultures for enhanced production of secondary metabolites **3P**
6. Transformation of plant tissues using *Agrobacterium tumefaciens* based vectors. Detection of transformants using GUS/GFP/gene specific PCR **4P**
7. Transformation of plant tissues using *Agrobacterium rhizogenes*. **4P**

BO 3.7d - Practicals on Biodiversity and Bioprospecting – Algae, Fungi – I **3C**

Biodiversity and Bioprospecting of Algae **(Any 6 Practicals)**

1. Collection, identification and documentation of algae from diverse habitats. **3P**
2. Study of tools in systematics of algae. **1P**
3. Study of pollution status of aquatic water body using algal indicators. **1P**
4. Documenting algal biofilm development on an artificial substratum/habitat **2P**
5. Preparation of algal herbarium **1P**
6. Collection and submission of photographs of unusual algal habitats **1P**
7. Study of SEM/TEM photographs of algae. **1P**
8. Studying bloom causing algae. **1P**
9. Control of bloom forming algae. **1P**
10. Karyological study of algae **1P**

Biodiversity and Bioprospecting of Fungi **(Any 6 Practicals)**

1. Determination of AM fungal diversity and abundance **2P**
2. Preparation of PDA, sterilization, pouring, inoculation and culturing of fungi. **2P**
3. Culture and identification of an unknown fungus from culture **2P**
4. Isolation and culture of fungi from rhizosphere. **2P**
5. Detection of various secondary compound from lichen thallus **2P**

BO 3.7e - Practicals on Biodiversity and Bioprospecting – Angiosperms – I

3C

(Any 12 practicals)

1. Comparative study of morphological and structural adaptations of hydrophytes, mesophytes, xerophytes, halophytes **2P**
2. Use of palynological, chemical methods in taxonomy **2P**
3. Construction of quadrats - to study species distribution, frequency, density, abundance in at least two herbaceous communities in different ecological regions **4P**
4. Use of molecular markers to determine genetic relatedness between species
 - a. ISSR / RAPD markers – DNA isolation, PCR amplification, scoring polymorphism **4P**
 - b. Construction of dendrograms using MEGA or other appropriate software (data provided) **2P**
 - c. Understanding population structure and dynamics using molecular markers (data provided) using POPgene or other appropriate software **2P**
 - d. Genic markers and their use in distinguishing species (using data available in NCBI database) **2P**

BO 4.1 – Quantitative methods and Bioinformatics	4C
Credit 1 - Statistics 1	15L
1. Populations and samples	1L
2. Data, graphical presentation of data – frequency distribution	1L
3. Mean, variance and standard deviation	1L
4. Sampling distributions, standard error of mean	1L
5. Normal (z) distribution, t distribution, confidence interval	3L
6. Hypothesis testing, type I and type II errors	3L
7. Binomial and Poisson distribution	3L
8. Non-parametric tests	2L
Credit 2 - Statistics 2	15L
1. Experimental designs- completely randomised, randomised block and factorial experimental designs	4L
2. Analysis of variance for different experimental designs, F distribution	4L
3. Correlation and regression, linear and non-linear regression,	4L
4. Chi-square test for goodness of fit and independence	3L
Credit 3 – Basic Bioinformatics	15L
1. Introduction to databases and retrieving information from databases: Databases	1L
2. Molecular tools in protein and nucleotide sequence analysis; origin of new genes and Proteins, gene duplication and divergence, Pattern searching	4L
3. Gene expression informatics; Introduction to gene finding	1L
Sequence similarities:	
a. Pairwise comparison of DNA and protein sequences, dynamic programming algorithms, FASTA and BLAST.	3L
b. Multiple sequence alignments, progressive methods, iterative methods, localized alignments.	3L
c. Determining phylogenetic relationships using DNA and protein sequences.	3L

Credit 4 – Structural Bioinformatics	15L
1. Protein structures, Ramachandran plot, protein folding,	3L
2. Structure function relationship, conformational energy calculations,	3L
3. Protein structure predictions, secondary and tertiary,	3L
4. Protein structure classification- SCOP, CATH,	3L
5. Immunoinformatics- epitope prediction	3L

References:

1. Statistical Methods – Snedecor G.W. and Cochran W.G. Affiliated East-West Press Pvt. Ltd. 1989.
2. Statistical methods in Agriculture and Experimental Biology – Mead, R. and Curnow, R.N. Chapman and Hall, 1983.
3. Practical statistics and experimental design for plant and crop science – Clewer, A.G. and Scarisbrick, A.H., John Wiley, New York, 2001.
4. Bioinformatics - Westhead, DR, Parish JH and Twyman, RM, BIOS Scientific Publishers Ltd., Oxford, 2003.
5. Bioinformatics – Sequence and genome analysis. D.W. Mount, CBS Publishers, New Delhi, 2003.
6. Bioinformatics and Molecular Evolution – Higgs PG and Attwood TK, Blackwell Publishing, Oxford, UK, 2005.
7. Bioinformatics A Practical Guide to the Analysis of Genes and Proteins- Baxevanis A. D., Francis Ouellette B. F. John Wiley & sons Inc., 2001.

BO 4.2a – Pharmacognosy – II **4C**

Credit I: Conservation of medicinal plants **15L**

- a. *In situ* conservation: Conventional propagation methods for cultivation of plants
- b. Factors affecting the cultivation of crude drugs. (I) Exogenous (II) Endogenous factors (III) Nutrients (IV) Soil and Soil fertility (V) Pest and Pest control (VI) Plant Growth Regulators (VII) Diseases management of medicinal and aromatic plants
- c. Systemic method of Cultivation and post harvest technology of medicinal plant, cultivated in India (i) Senna (ii) Opium (iii) Aswaghandha (iv) Lemon Grass (v) Turmeric (vi) Ginger
- d. *Ex-situ* conservation methods: Types of culture systems used for secondary metabolite production
- e. Organized growth in cultures : using preexisting meristems, organogenesis and embryogenesis
- f. Micropropagation of medicinal plants w. r. t. Culture media, explants, incubation conditions, stages of micropropagation, acclimatization and field trials.

Credit II: Manipulation of cultures for enhanced production of secondary metabolites **15L**

- a. Screening and selection of high secondary metabolite producing cell lines
- b. Manipulations of secondary metabolite production in cultures
 - I. Manipulation of culture media.
 - II. Immobilization of cells.
 - III. Elicitation using biotic and abiotic elicitors.
 - IV. Biotransformation.
 - V. Elicitation
- c. Scaling up and use of Bioreactors:
 - I. Strategies used for mass cultivation for production
 - II. Types of bioreactors
 - III. Case studies

Credit III: Engineering of secondary metabolite pathways and molecular pharming:

1. Tools for metabolism engineering **4L**
 - a. Agrobacterium mediated transformation
 - b. Direct DNA transfer
 - c. Plant based vectors
 - d. Cloning desired genes
2. Modifications of plant secondary metabolism by genetic engineering: case studies **1L**
3. Genetic engineering of enzymes diverting amino acids into secondary metabolites **2L**
4. Transcriptional regulators to modify secondary metabolites **2L**
5. Modulation of plant function and plant pathogens by antibody expression **1L**
6. Altering biosynthetic pathways using antisense technology, Modifying existing pathways by introduction of genes coding for biosynthetic enzymes from other organisms **2L**
7. Genetic engineering for production of biopharmaceuticals – vaccines, antibodies **1L**
8. Strategy to identify possible drug target molecules, parameters and strategies for drug discovery using bioinformatics. **2L**

Credit IV: Screening and evaluation of phytochemicals**15L**

- a. Brief information about various chemical and biological activities of plant drugs reported in literature
- b. Study of pharmacological screening methods of the following categories of drugs: Antimicrobial, antioxidants, anticancer, hypolipidemic, diuretics, cardiovascular, hepatoprotective, antidiabetic, immunomodulatory and antimalarial w. r. t. mechanism of action and property of drug being used.
- c. Import and export of medicinal plants / crude drugs. Criteria potential for exports - Plants, crude drugs, crude extracts, products etc. Export agencies,
- d. Intellectual property right and Patents in relation to pharmacognosy

References

1. Smith, P. M. (1976) Chemotaxonomy Of Plants. Publ. Edward Arnold, UK
2. Swain, T. E., 1966, Chemical Plant Taxonomy, Academic Press, London and New York.
3. Tayler, V.E.; Brady, L.R. and Robber, J. R. 1976, Pharmacognosy, Balliere Tindall, Calcutta.
4. Trease and Evans, 1972, Pharmacognosy, Lea and Fobiger, Philadelphia.
5. Wagner, H. 1984, Plant Drug Analysis.
6. Wagner, H., 1977, New Natural Products and Plant Drugs with Pharmacological, Biological or Therapeutical Acitivity.
7. Wallis, T. E., 1967, Practical Pharmacology.
8. Wallis, T.E. 1967 Textbook of Pharmacognosy, J and A Churchill LTD, London.
9. Dewick Paul M. 1998 Medicinal natural products (a biosynthetic approach), Ist edn, by, John Wiley and sons Ltd., England.
10. Pushpangadam P., Nyman UIF., George V, 1995 , Glimpses of Indian Ethanopharmacology Tropical botanic Gardon and research institute.,
11. Peter B. Kaufman 1998 Natural Products from plants, Ist edn, by, CRC press, Newyork,
12. Farooqui A. A. and Shreeramu B.S. 2001 Cultivation of medicinal and aromatic crops, 1st edn, University press, new Delhi.
13. Schirmer, R.E., 2000, Modern Methods of Pharmaceutical Analysis, Vol. 1, 2, Boca Raton F.L: CRC Press
14. Indian Pharmacopoeia 2007.
15. European Pharmacopoeia 6th Edn. 2008.
16. Ramavat, K. G., 2003, Plant Biotechnology, S. Chand And Co. Ltd.

17. Greene JJ and Rao VS, 1998. Recombinant DNA – Principles and Methodologies. Marcel Dekker, New York,
18. Primrose SB, Twyman 2001, RM Principles of gene manipulation. and Old RW, 6th Edition, Blackwell Science, Oxford,
19. Collins GB and Shepherd RJ Eds. 1996 Engineering plants for commercial products and applications, NY Acad. Of Science Publishers
20. Senson CW ed. 2002. Essentials of Genomics and Bioinformatics, Wiley-VCH Publishers, NY,
21. Morris, A.H. et al., Eds 1986. Secondary Metabolism in Plant Cell Cultures, Cambridge Univ. Press, Cambridge, U.K.
22. Staba, E.J., Ed. 1980 Plant Tissue Culture as a Source of Biochemicals,. C.R.C. Press. Boca Raton, Florida.
23. Kurz W.G.W., Ed. 1989, Primary and Secondary Metabolism of Plant and Cell Cultures,. Springer Verlag, Berlin.
24. Bajaj, Y.P.S., Ed. (1988) Biotechnology in Agriculture and Forestry – vol. 4, Springer-Verlag, Berlin, Heidelberg, New York, Tokyo.
25. Vasil I.K. ed (1986) Cell culture and somatic cell genetics of plants Vol. 4, Academic Press, N.Y.
26. Charlwood B.V. and Rhodes MV. Edt (1999), Secondary products from plant tissue culture.. Clarendon Press, Oxford.
27. Dicosmo F and Misawa M, Edt (1996), Plant cell culture: Secondary metabolism towards industrial application, CRC press, Boca Raton, N.Y.
28. Ramawat K G and Merillon J M, Edt. (1999) Biotechnology: Secondary metabolites, Oxford IBH Publishing Co., New Delhi
29. Buchanan BB, Grussem W and Jones RL (2000) Biochemistry and molecular biology of plants, IK International Pvt Ltd. New Delhi
30. Verapoorte r and Alferman HW (eds), 2003 Metabolic engineering of plant secondary metabolites. Kluwar Academic Publ., Netherlands.

BO 4.2b - Ecophysiology –II	4C
Credit 1- <i>In vitro</i> culture and genetic transformation of plants	15L
1. <i>In vitro</i> responses of plant cells, tissue and organs- effect of nutrient medium constituents, growth regulators and environmental factors.	3L
2. Physiological and genetic basis of somaclonal variation and their applications	1L
3. Protoplast culture, somatic hybridization and cybridization, production of haploids	2L
4. Secondary metabolite production in cultured plant cells and tissues	2L
5. Genetic transformation of plants - transfer of foreign DNA into host plant tissues using <i>Agrobacterium</i> based vectors, mechanism of integration of DNA into plant genomes.	3L
6. Factors affecting transformation, Screening and analysis of transformants.	2L
7. Direct DNA transfer to plants – Electroporation, biolistic transfer	2L
Credit 2- Responses of plants to drought, salinity and temperature stress	15L
1. Drought stress – effects on growth and metabolism in plants	2L
2. Acclimation responses to drought stress at physiological and molecular level, stress signaling.	3L
3. Adaptive responses to drought stress, drought escape, tolerance	2L
4. Salinity stress – osmotic and ionic effects on growth and metabolism	2L
5. Mechanisms for removal of sodium from cells - SOS pathway, NHX transporters	1L
6. Improvement of salinity tolerance in plants	1L
7. Stress due to extreme temperatures – effects on growth and metabolism	2L
8. Adaptive responses of plants to low and high temperature stress	2L
Credit 3- Chemical signaling in plant interactions	15L
1. Role of hormones and secondary metabolites in signaling during plant interactions	1L
2. Allelo-chemicals and their ecological role	2L
3. Symbiotic interactions of plants with rhizobia and mycorrhiza. Signaling mechanisms leading to successful symbiosis.	4L
4. Chemical signaling during interactions of plants and pathogens, physiological interactions leading to expression of resistance or susceptibility.	4L
5. Chemical signaling in plant interactions of plants and herbivores, pollinators	4L

- Credit 4 - Xenobiotic agents and phytoremediation** **15L**
1. Metal ions Na, Pb, Cr, Cd and their toxic effects on plant growth and metabolism. **2L**
 2. Toxic effects of hydrocarbons, chlorinated solvents, pesticides and radionuclides on plants. **3L**
 3. Phytoremediation – Methods used by plants to clean soils, extraction and accumulation, filtration, volatilisation, stabilisation, degradation **3L**
 4. Plants used for phytoremediation and the mechanism involved – case studies. **4L**
 5. Use of transgenic plants for phytoremediation. **3L**

References :

1. Berg J.M., Tymoczko J.L., Stryer L. (2002) Biochemistry. 5th Ed. Wlt. Freeman and Company, New York.
2. Buchanan B.B., Grissem W., Jones R.L. (2000) Biochemistry and Molecular Biology of Plants. IK International, Mumbai.
3. Calliot W.H., Elliot D.C. (1997) Biochemistry and Molecular Biology. Oxford University press, New York.
4. Davis P. J. (Eds.).(2004) Plant Hormones. Kluwer Academic Publishers, Dordrecht, Netherlands.
5. Goodwin T.W., Mercer E.I. (1998) Introduction to Biochemistry. CBS Publishers, New Delhi.
6. Heldt H. W. (2004) Plant Biochemistry. Academic Press, California.
7. Lawlor D.W. (2001) Photosynthesis. 3rd Ed. Viva. New Delhi.
8. Nelson David and Cox Michael. (2007) Lehninger Principles of Biochemistry. W.H.Freeman and Company. New York.
9. Lincoln Taiz and Eduardo Zeiger (2010) Plant Physiology, Fifth edition. Sinauer Associates, Inc. Publishers. Sunderland, USA.

Periodicals and Journals

1. Trends in Plant Sciences
2. Annual Review of Plant Biology
3. Plant Cell
4. Plant Physiology
5. Journal of Plant Physiology
6. Physiologia Plantarum
7. Physiology and Molecular Biology of Plants

BO 4.2c - Plant Biotechnology – II	4C
Credit 1 - Plant genome, transcriptome and proteome	15L
1. Fundamental gene set, evolution and elaboration of plant genomes – whole genome duplication and divergence, lineage-specific variation, synteny	3L
2. Genomic databases and their application in comparison of genomes	2L
3. Plant transcriptome, annotating genomes, alternative splicing, RNA editing, alternative transcription initiation and termination sites	2L
4. Plant proteome – techniques 2-D electrophoresis, MALDI-TOF, LC-MS-MS, Analysis of proteome data, protein chips and arrays. Protein databases and their applications.	4L
5. Protein-DNA and protein-protein interactions – Chromatin immunoprecipitation assays, gel mobility shift assays, yeast 2-hybrid system, affinity chromatography, GST-pull down etc	4L
Credit 2- Gene expression	15L
1. Techniques used to study gene expression at transcription level: Northern hybridization, reverse northern hybridization, differential screening and subtractive hybridization, differential display of mRNA, ESTs, SAGE, cDNA-AFLP, DNA microarrays.	6L
2. Promoter and enhancer traps, promoter motifs, promoter analysis.	2L
3. Studies on alterations in gene expression: Site-directed mutagenesis, Insertional mutagenesis, knock out mutants, targeting induced local lesions in genomes (TILLING).	3L
4. Gene silencing - Gene inhibition at RNA level - antisense, co-suppression, miRNAs and siRNAs. Silencing mechanisms.	4L
Credit 3: Molecular markers and their applications	15L
Molecular markers: Different types of molecular markers, Genic and random markers, Hybridization-based techniques and PCR based techniques – RAPD, AFLP, SSR polymorphism, microsatellite-primed PCR, sequence-based polymorphism, single nucleotide polymorphism (SNP).	5L
Applications of molecular markers: Diversity studies, DNA fingerprinting, population structure studies, phylogenetic relationships - distance based, maximum likelihood, maximum parsimony methods.	5L
Genetic maps using molecular markers, map based cloning, mapping populations.	2L
QTL analysis and marker assisted selection.	3L
Credit 4 Transgenic Plants: Applications	15L
1. Target genes for improving:	
a. Resistance against pathogens and pests – Case studies	4L
b. Abiotic stress tolerance – Case studies	4L

2. Genetic engineering for production of food, biopharmaceuticals and other useful products – vaccines, antibodies, growth factors etc. Case studies **5L**
3. Regulations regarding GMOs– Potential problems with GMOs, efforts to prevent these problems, gene containment, excision of antibiotic resistance markers from transformed plants. Regulatory bodies in government. **2L**

References:

1. Recombinant DNA – Principles and Methodologies. Greene JJ and Rao VS, Marcel Dekker, New York, 1998.
2. Principles of gene manipulation. Primrose SB, Twyman RM and Old RW, 6th Edition, Blackwell Science, Oxford, 2001
3. Differentially expressed gene in plants. Hansen and Harper, Taylor and Francis Ltd. London, 1997.
4. Engineering plants for commercial products and applications. Eds. Collins GB and Shepherd RJ, NY Acad. Of Science Publishers 1996
5. DNA markers. Eds. Caetano-Anolles and Gresshoff, Wiley-VCH Publishers, NY, 1998
6. Introduction to Bioinformatics. Attwood, T.K., Parry-Smith, DJ, Addison Wesley Longman, Harlow, Essex, 1999
7. Bioinformatics. Westhead, DR, Parish JH and Twyman, RM, BIOS Scientific Publishers Ltd., Oxford, 2003
8. Bioinformatics – Sequence and genome analysis. D.W. Mount, CBS Publishers, NewDelhi, 2003
9. Collins GB and Shepherd RJ Eds., 1996, Engineering plants for commercial products and application. , NY Acad. Of Science Publishers
10. Senson CW Edt, 2002, Essentials of Genomics and Bioinformatics,. Wiley-VCH Publishers, NY,
11. Charlwood B.V. and Rhodes MV Edt. 1999, Secondary products from plant tissue culture. Clarendon Press, Oxford.
12. Dicosmo F and Misawa M, Edt 1996, Plant cell culture: Secondary metabolism towards industrial application, CRC press, Boca Raton ,N.Y.
13. Ramawat K G and Merillon J M, Edt.,1999 Biotechnology: Secondary metabolites, Oxford IBH Publishing Co., New Delhi
14. Buchanan BB, Grussem Wand Jones RL ,2000 , Biochemistry and molecular biology of plants , IK International Pvt Ltd. New Delhi
15. Verapoorte R and Alferman HW Eds ,2002 Metabolic engineering of plant secondary metabolites. Kluwar Academic Publ., Netherlands

Relevant review articles from journals

Credit 1:

1. Bioprospecting of micro-algae: Phyco-remediation, Animal feed, feedstock for anaerobic processes, algal vaccines, algal biofuels, biological hydrogen production from algae, biofertilizer, Lipid identification and extraction techniques, other value added products from microalgae (Pigments, vitamins, food supplements, fatty acids), cosmetics, applications of spent biomass, diatomaceous earth in industries. **8L**
2. Antimicrobial and anticancer compounds from microalgae, other secondary metabolites from microalgae. **3L**
3. Cultivation of Microalgae: Cultivation methods used for different algal groups, Role of physical and chemical factors on cultures, scaling up, growth kinetics and measurements, harvesting, synchronous and continuous cultures. **4L**

Credit: 2

1. Bioprospecting of macro-algae: Bioprospecting of marine algae, Present and future prospects of seaweeds in developing functional foods, Bioactive metabolites from seaweeds, In-vivo and in-vitro studies of seaweed compounds, chemical ecology of seaweeds, anticoagulant effect, seaweeds and man. **5L**
2. Conventional and alternative technologies for the extraction of algal polysaccharides (Alginates, agar, Carrageenan), Phlorotannins. **3L**
3. Cultivation of Macroalgae: Introduction, type of seaweed farming, Necessity, cultivation of *Porphyra*, *Eucheuma*, *Gracilaria* and *Laminaria*. Environmental impact of seaweed cultivation, Seaweed mariculture in Indian subcontinent. **3L**
4. Intellectual property rights associated with algal bioprospecting **1L**
5. Conservation of micro and macro algae: Threats to freshwater and marine algae, Threatened algal species and ex-situ conservation, Role of culture collections and natural history museums in conservation and exploration of algal diversity. **3L**

Credit: 3

1. AM fungi and their application in forestry, agroforestry and restoration/ reclamation of waste land. **3L**
2. Utilization of fungi for production of metabolites: primary and secondary, Fungal secondary metabolite from biochemistry to genomics. Therapeutic proteins from fungi, fungal immunomodulatory proteins, bioactive compound from endophytic fungi. **8L**
3. Medicinal fungi: antibiotics from fungi, Product of pharmaceutical importance of fungi, pharmacological importance of *Cordyceps*. **4L**

Credit: 4

1. Lichens as sources of secondary metabolites, pathway of secondary metabolites in lichen and their applications. **4L**

2. Exploiting fungi for a food: fungi as a food, Mushrooms and other edible fungi, fungi in food web, cell and mycelium as human food, fermented product. Nutraceuticals **4L**
3. Fungi as biosensors. **2L**
4. Industrially important fungal enzymes **2L**
5. Fungal genomics: Agricultural mycocides: Srobilurins **3L**

References: Biodiversity and Bioprospecting of algae

1. Andersen, R. A. (ed.) (2005). Algal culturing techniques. Elsevier Academic Press, pp. 578.
2. Barsanti, L. and Gualtieri, P. (2006). Algae: anatomy, biochemistry and biotechnology. CRC Press, pp. 301.
3. Benson, E. E. (ed.) (1999). Plant conservation biotechnology. Taylor & Francis, pp. 309.
4. Bhattacharya, D (ed). (1997). Origin of algae and their plastids. Springer-Verlag, New York, pp. 287.
5. Bux, F. (ed.) (2013). Biotechnological applications of microalgae- biodiesel and value added products. CRC Press, pp. 227.
6. Caldwell, M. M., Heldmaier, G., Jackson, R. B., Lange, O. L., Mooney, H. A., Schulze, E. D. and Sommer, U. (eds.) (2012). Seaweeds biology-Novel insights into ecophysiology, ecology and utilization. Springer-Verlag, pp. 510.
7. Dominguez, H. (ed.) (2013). Functional ingredients from algae for foods and nutraceuticals. Woodhead Publishing Ltd., UK., pp. 734.
8. Evangelista, V., Barsanti, L., Frassanito, A. M., Passarelli, V. and Gualtieri, P. (eds.) (2008). Algal toxins: nature, occurrence, effect and detection. Springer, pp. 399.
9. Gouveia, L. (2011). Microalgae as a feedstock for biofuels. Springer, New York, pp. 69.
10. Gupta, R. K. and Pandey, V. D. (eds.) (2007). Advances in applied Phycology. Daya Publishing House, Delhi, pp. 299.
11. Kim, S. K. (ed) (2011). Marine medicinal foods: Implications and applications macro and microalgae. Elsevier Inc., pp. 466.
12. Kim, S. K. (ed.) (2012). Handbook of marine macroalgae-biotechnology and applied Phycology. Wiley Blackwell, pp. 567.
13. Kristiansen, J. (ed.) (1996). Biogeography of freshwater algae. Springer Science+Business Media, pp. 161.

14. Leon, R., Galvan, A. and Fernandez, E. (eds.) (2007). *Transgenic microalgae as green cell factories*. Landes Biosciences and Springer Science+Business Media, LLC, U.S.A., pp. 128.
15. Lobban, C. S. and Harrison, P. J. (1997). *Seaweed ecology and physiology*. Cambridge University Press, pp. 366.
16. Pandey, A., Lee, D. J., Chisti, Y. and Soccol, C. R. (eds.) (2014). *Biofuels from algae*. Elsevier, pp. 338.
17. Richmond, A. and Hu, Q. (eds.) (2013). *Handbook of microalgal culture-applied Phycology and biotechnology*. Wiley Blackwell, pp. 719.
18. Sarma, T. A. (2013). *Handbook of cyanobacteria*. CRC Press, pp. 802.
19. Seckbach, J. and Kociolek, J. P. (2011). *The diatom world*. Springer, pp. 534.
20. Stoermer, E. F. and Smol, J. P. (eds.) (2004). *The diatoms: applications for the environmental and earth sciences*. Cambridge University Press, 469.
21. Whitton, B. A. (ed.) (2012). *Ecology of cyanobacteria II-Their diversity in space and time*. Springer, pp. 760.
22. Zajic, J. E. (ed.) (1970). *Properties and products of algae*. Plenus Press, New York-London, pp. 154.

References: Biodiversity and Bioprospecting of Fungi

1. Hibbett DS, Binder M, Bischoff JF, Blackwell M, Cannon PF, Eriksson OE, *et al.* (2007). "A higher level phylogenetic classification of the *Fungi*" (PDF). *Mycological Research* 111(5): 509–547. doi:10.1016/j.mycres.2007.03.004. PMID 17572334.
2. 21century guidebook of fungi, David Moore, Geoffrey D. Robson, Anthony P. J. Trinci:Cambridge university press. 2011
3. *Introduction of Fungi* by John Webster and Roland Weber, Third edition, Cambridge University Press, 2007.
4. *Introductory Mycology* by Alexopolous J., Mims C. W. and M. Blackwell, fourth edition, Wiley India Pvt Ltd, 2007.
5. *Topics in Mycology and Pathology* by L. N. Nair, first edition, New Central Book Agency Kolkata, 2007.
6. *Fungal Biology* by J. W. Deacon, forth edition, Blackwell Publishing Ltd, 2006.
7. *Biodiversity of fungi: Inventory and Monitoring methods* by M. S. Foster, G. F. Wills and J. M. Mueller, first edition, Academic Press, 2004.
8. *Mycoremediation: Fungal Bioremediation* by Harbhajan Singh, first edition, John Wiley and Sons, Hoboken, New Jersey, 2006.

BO 4.2e - Biodiversity and Bioprospecting of Angiosperms – II **4C**

Credit 1

1. Plant Interactions - Allelopathy, competition, parasitic plants, epiphytic plants. **3L**
2. Symbiotic associations- mycorrhizae, endophytes, root nodulation **3L**
3. Herbivory – insects, grazing animals – Plant signaling and defense against herbivores. **3L**
4. Carnivory – morphological features, specialized biochemical mechanisms for nutrient processing **2L**
5. Pollination - mechanisms, mimicry, thermogenesis, co-evolution of plants and pollinators. **4L**

Credit 2

1. Conservation: *ex-situ* and *in-situ*, clonal propagation, micropropagation, IUCN categories, agrotechniques. **15L**

Credit 3

1. Polymers of plant origins – Cellulose, lignin, starch, waxes, suberins, rubber – Their chemical diversity, localisation and uses. **15L**

Credit 4

1. Other useful plant products – Oils, pigments, phenolics, terpenoids, alkaloids – Their chemical diversity, localisation and uses. **15L**

Reference Books:

1. Krishnamurthy K.V. (2003) An Advanced Textbook on Biodiversity-Principles and Practice, Oxford & IBH Publ. New Delhi.
2. Handbook of the Convention on Biological Diversity (2001), Secretariat of the Convention on Biological Diversity. Earthscan publ., London.
3. An Advanced Textbook on Biodiversity-Principles and Practice (2003), K.V. Krishnamurthy, Oxford & IBH Publ. New Delhi.
4. Biodiversity and Conservation (2005), Michael J. Jeffries, Routledge, London.
5. Handbook of Biodiversity Methods – Survey, Evaluation and Monitoring (2004) Edt.- David Hill, Matthew Fasham, Graham Tucker, Michael Shewry & Philip Shaw; Cambridge.
6. This Fissured Land: An Ecological History of India (1992) Gadgil M. & Guha R.; Oxford University Press, New Delhi.
7. Restoration of Endangered Species (1996) edt- Bowles M.L. & Whelan C.J.; Cambridge Univ. Press.

8. Preservation and Valuation of Biological Resources (1990); Orians GH, Brown GM, Kunin WE & Swierbinski JE.; Univ. Washington Press.
9. Paradise Lost? The Ecological Economics of Biodiversity (1994); Barbier EB, Burgess JC & Folke C.; Earthscan, London.
10. Molecular Markers, Natural History and Evolution (1994), Avise JC; Chapman & Hall, London.
11. Forest Genetic Resources: Status, Threats and Conservation Strategies (2001), Uma Shaanker, R.Ganeshiah, KN. & Bawa KS (Eds); Oxford & IBH, New Delhi.
12. Global Biodiversity Strategy: Guidelines for Action to Save, Study, and Use Earth's Biotic Wealth Sustainably and Equitably (1992) WRI/IUCN/UNEP; WRI Publ, Baltimore, MD.
13. Plant Diversity Hotspots in India – An Overview (1997) Edt.- Hajra P.K. & V. Mudgal, BSI.
14. The Economics of Biodiversity Conservation (2007), K.N. Ninan, Earthscan, London.

BO 4.3 Project on BO 4.2 – All Specializations

BO 4.4 - Practicals on Quantitative methods and Bioinformatics**4C****(Any 16 practicals)****Biostatistics****(Any 8 practicals)**

1. Data, graphical presentation of data – frequency distribution **1P**
2. Sample means and standard deviations, confidence intervals **1P**
3. Distribution of sample means, standard error **1P**
4. Hypothesis testing-comparison of means **2P**
5. Chi-square test **1P**
6. Analysis of variance **2P**
7. Correlation and regression **2P**

Bioinformatics**(Any 8 practicals)**

1. Databases and database searching **1P**
- DNA and protein sequence comparisons:
1. Pairwise comparison of DNA and protein sequences - BLAST **2P**
 2. Multiple sequence alignments, progressive methods, CLUSTAL **2P**
 3. Determining phylogenetic relationships using DNA and protein sequences **2P**
 4. Visualizing protein 3D structure **1P**
 5. Prediction of 3D structure of proteins using homology modeling **1P**
 6. Assessment of homology modeled protein structure **2P**

BO 4.5a - Practicals on Pharmacognosy II

4C

(Any 16 practicals)

1. Micropropagation of a plant through multiplication of pre-existing meristems **3P**
2. Micropropagation of a plant through organogenesis **2P**
3. Detection and estimation of alkaloids in callus of suitable medicinal plants **1P**
4. Study of growth and secondary metabolite production in cell suspension cultures **2P**
5. Elicitation of plant cells for secondary metabolites **1P**
6. Screening for biological activities Antimicrobial screening of Herbal drugs/Extracts **2P**
7. Antifungal screening of Herbal drugs/Extracts **2P**
8. Anticancer activity by MTT assay **2P**
9. Antioxidant activity of herbal drugs/extracts **1P**

BO 4.5b - Practicals on Ecophysiology II

4C

(Any 16 practicals)

1. Studies on depletion of mineral elements from media and accumulation in *in vitro* cultured plant tissues using Atomic absorption spectrometry **3P**
2. Studies on effect of growth regulators on *in vitro* responses of plant tissues **3P**
3. Genetic transformation of tobacco using *Agrobacterium tumefaciens* based vector and screening for transformants **3P**
3. Studies on superoxide dismutase, catalase and peroxidase activity in response to drought stress / xenobiotic stress / pathogen application **3P**
4. Studies on proline accumulation in plants exposed to salinity stress. **1P**
5. *In situ* localization of superoxide and hydrogen peroxide in pathogen tolerant and susceptible genotypes in response to pathogen application **2P**
6. Estimation of change in MeJA levels in plants infected with pathogen using Gas chromatography **3P**
7. Studies on accumulation of heavy metals in hyperaccumulator plants / tissues using Atomic absorption spectrometry **2P**

BO 4.5c - Practicals on Plant Biotechnology II

4C

(Any 16 practicals)

1. DIG – labeling of DNA fragment for use as probe in Southern hybridization. **3P**
2. Restriction and electrophoresis of plant genomic DNA, Southern blotting and Southern hybridization. **3P**
3. RNA isolation from plant tissues and electrophoresis of RNA. **3P**
4. RT-PCR and comparing gene expression in two treatments. **3P**
5. Use of PCR-based molecular markers- RAPDs, ISSR markers for scoring polymorphism. Construction of phylogenetic trees using given data **2P**
8. Making linkage maps from given data using mapmaking software. QTL analysis using given data **2P**
9. Separation and detection of specific proteins using Western blotting **3P**
10. Bioinformatic tools to study protein structure **2P**

BO 4.5d - Practicals on Biodiversity and Bioprospecting – Algae, Fungi II **4C**

Algae **(Any 8 Practicals)**

1. Culturing of microalgae: Isolation, purification and maintenance. **3P**
2. Qualitative and quantitative analysis of algal lipids. **2P**
3. Estimation of algal pigments (Carotenoids, Phycobiliproteins) **2P**
4. Enrichments of algal cultures. **1P**
5. Immobilization of algae **1P**
6. Preparation of Single Cell Protein **1P**
7. Preparation of Seaweed Liquid Fertilizer **2P**
8. Survey of market products of algal materials **1P**
9. Algal growth measurements and growth curve studies **2P**
10. Lyophilization of algal samples and testing for viability **2P**
11. Preparation of BGA biofertilizer **2P**
12. Extraction and purification of Agar-agar and alginates **2P**
13. Compiling algal collection centres across globe. **1P**
14. Raising algae from soil samples by Biphasic methods **2P**

Fungi **(Any 8 Practicals)**

1. Quantitative estimation of Cellulases/ Pectinases from wood degrading fungi **2P**
2. Isolation and culture of aquatic fungi by baiting method. **2P**
3. Production and estimation of citric acid from *Aspergillus niger* **2P**
4. Production of Penicillin and testing of antimicrobial activity **2P**
5. Testing action of fungicides on fungal cultures **2P**

BO 4.5e - Practicals on Biodiversity and Bioprospecting -Angiosperms II **4C**

(Any 16 Practicals)

1. Morphology and anatomy of epiphytes and parasitic plants. **2P**
2. Study of floral biology, visitations by pollinators, pollen viability, self and cross pollination, seed set of any two species. **4P**
3. Studies on mycorrhizal association with roots – intra and extra radical mycelia, arbuscules, effect of symbiosis on growth of plants in N or P limiting soils. **4P**
4. Ex situ conservation methods of biodiversity – through seed, vegetative and micro-propagation methods. (any one plant species per technique) **4P**
5. Field trips to places for study and observation of vegetation types. (including any one plant diversity hotspots / National Parks/ Wildlife Sanctuary) **3P**
6. Studies on anatomy of different types of wood. **2P**
7. Studies on fatty acid composition of oils from any two oilseed plants using Gas chromatography. **2P**
8. Remote sensing techniques for vegetation/ plant diversity assessment using satellite Imagery. Data analysis. **2P**