DRAFT COURSE STRUCTURE OF M. Sc. SYLLABUS

TO BE IMPLEMENTED FROM July 2011 (semester I & II)
And July 2012 (semester III &IV)

Semester I		**(26 cr.)**
Course No.	**Title of course**	**Credits allotted CC**
BO 1.1	Plant Systematics I (Algae, fungi & Bryophytes)	**4**
BO 1.2	Biochemistry and Plant Physiology	**4**
BO 1.3	Genetics & Plant breeding	**4**
BO 1.4	Tools and Techniques in Botany	**4**
BO 1.5	Practicals based on BO 1.1 and 1.4	**5**
BO 1.6	Practicals based on BO 1.2 & BO 1.3	**5**
Semester II		**(26 cr.)**
BO 2.1	Plant Systematics II (Pteridophytes and Gymnosperms)	**4**
BO 2.2	Cell Biology	**4**
BO 2.3	Molecular Biology	**4**
BO 2.4	Plant Ecology	**4**
BO 2.5	Practicals based on BO 2.1 and 2.4	**5**
BO 2.6	Practicals based on BO 2.2 & 2.3	**5**
Semester III		**(26 cr.)**
BO 3.1	Plant Systematics III (Angiosperms)	**4**
BO 3.2	Developmental Botany	**4**
BO 3.3	Plant Genetic engineering	**4**
BO 3.4	Quantitative methods and Bioinformatics	**4**
BO 3.5	Practicals on BO 3.1 and BO3.2	**5**
BO 3.6	Practicals on BO 3.3 and BO3.4	**5**
Semester IV		**(22 cr.)**
BO 4.1	Optional paper I	**4**
BO 4.2	Optional paper II	**4**
BO 4.3	Practicals on optional paper II	**4**
BO4.4	Project on optional paper II	**8**
BO4.5	Review and Seminar on optional paper II	**2**
1. **Optional paper I will consist of the following options: (any one)**		
4.1a	Plant Pathology	**4**
4.1b	Plant diversity assessment and conservation	**4**
4.1c	Clonal propagation of plants	**4**
4.1d	Plant Organism interactions	**4**
2. **Optional paper II will consist of the following options: (any one)**		
4.2a	Advanced plant physiology	**4**
4.2b	Advanced angiosperm systematics and evolution	**4**
4.2c	Algology - Diversity and applications of algae	**4**
4.2d	Mycology - Diversity and applications of fungi	**4**
4.2e	Pharmacognosy - Medicinal plant biology	**4**
4.2f	Plant biotechnology	**4**
4.2g	Advanced Genetics and Plant breeding	**4**
4.2h	Advanced Environmental Botany	**4**

BO 3.1 Plant Systematics III Angiosperms

Credit 1 **(15 L)**

1. Systematics –taxonomy and systematics. Definitions, Phases Scopes and importance **2L**
2. Systematics as a synthetic discipline; principles and goals; sources of data and selection of characters for Systematics **;** Morphology, Anatomy, Embryology, Cytology, Palynology, Phytochemistry, Micromorphology, Molecular biology **6L**
3. Tools of taxonomy - Floras, Revisions and Monographs : Floras, Revisions and Monographs as basis of taxonomy; components; design and methods of floristics and revisionary / monographic studies; role of herbaria; botanic gardens and literature in taxonomic studies; important literature resources **4L**
4. Biosystematics –Introduction, Biosystematic categories **1L**
5. Floristics – Principles and procedure **1L**
6. Principles of Numerical taxonomy **1L**

Credit 2 **(15L)**

1. Basis, outline and special features of Cronquist's system (1988) of classification of flowering plants. **3L**

Salient features, classification and interrelationship of the constituent taxa **12L** (up to family) of the following subclasses of Liliopsida Alismatidae, Arecidae, Commelinidae, Zingiberidae and Lilidae

Credit 3 **(15L)**

Salient features, classification and interrelationship of the constituent taxa (up to family) of the following subclasses of Magnoliopsida – Magnoliidae, Hamamelidae, Caryophyllidae, Dilleniidae, Rosidae Asteridae

Creidt 4 **(15L)**

Systematics and features of biological interest in

Aquatic angiosperms **3L**

Parasitic angiosperms **4L**

Epiphytic angiosperms **2L**

Insectivorous angiosperms **3L**

Mangroves **3L**

References:

1. Agashe SN (1995) Paleobotany, Oxford and IBH Publ. Co. Pvt. Ltd, New Delhi.
2. Cronquist A J (1988). Evolution and Classification of Flowering Plants, 2nd edn, N Y Botanical Garden.
3. Davis P H and Heywood V H (1963). Principles of Angiosperm Taxonomy, Oliver and Boyd.
4. Eames A J (1961). Morphology of Angiosperms, McGraw Hill Book Co.

5. Erdtman G (1966). Pollen Morphology and Plant Taxonomy of Angiosperms (An introduction to Palynology I), Hafner Pub. Co. London.

6. Kubitzki K (1977). Flowering Plants Evolution and Classification of Higher Categories. Plant Systematics – Evolution Supplement I.

7. Kuijt J. (1969). The biology of parasitic flowering plants. California University Press.

8. Naik V N (1984). Taxonomy of Angiosperms, TMH, New Delhi.

9. Radford A E (1986). Fundamentals of Plant Systematics, Harper and Row N Y.

10. Singh G (2004). Plant Systematics, 2nd edn, Oxford and IBH, New Delhi.

11. Sivrajan V V (1984). Introduction to Principles of Plant Taxonomy, Oxford and IBH, New Delhi.

12. Smith P M (1976). The Chemotaxonomy of Plants, Edward Arnold Pub. Ltd.

13. Sporne K R (1974). Morphology of Angiosperms, Hutchinson University Library, London.

14. Stace C A (1989). Plant Taxonomy and Biosystematics.

15. Stewart W N and Rothwell G W (2005). Paleobotany and the Evolution of Plants, 2nd edn, Cambridge University Press.

16. Subrahmanyam K. Aquatic angiosperms. BSI. India

17. Cook T (1903). The Flora of Presidency of Bombay, Vol. I (Indian Reprint) Bishen Singh, Mahendra Pal Singh, Dehradun.

18. Cook T (1903). The Flora of Presidency of Bombay, Vol. II (Indian Reprint) Bishen Singh, Mahendra Pal Singh, Dehradun.

19. Hickey M and King C (2000). The Cambridge Illustrated Glossary of Botanical Terms. Cambridge University Press, UK.

20. Jain S. K. and Rao R. R. Handbook of Field and Herbarium Methods, Today and Tomorrow Publishers, New Delhi.

21. Jones S B and Luchinger A E (1986). Plant Systematics 2nd edn, McGraw Hill Book Co
.
22. Lawrence G H M (1951). Taxonomy of Vascular Plants, Macmillan.

23. Mabberly T J (1997). The Plant Book 2nd edn Cambridge University Press, Cambridge.

BO 3.1 Developmental Botany

Credit 1 - 4 Credits (**15L)**

1. Plant development – Concept, definitions and unique features. **1L**

2. Processes basic to plant development

   a) Competence, determination, commitment, specification, induction, differentiation, dedifferentiation and redifferentiation. Morphogenetic gradients, cell fate and cell lineages.
   b) Polarity and symmetry
   c) Programmed cell death, aging and senescence. **4L**

3. Vegetative development – structure and organization of seed embryo.
   Meristems, Meristems as dynamic centers of cell regeneration, types and activities of meristems. Organization of shoot and root apical meristems,
   Embryonal axis, establishment of seedling organs, Organ development – Primordium to organ development of root stem and leaf. **6L**

4. Juvenility – characteristics, transition to adult phase. **1L**

5. Coordinated development – pattern formation – branching, phyllotaxy, aestivation
   Developmental basis of plant forms (in terms of longevity and habit) **3L**

Credit 2 **(15L)**

1. Transition from vegetative to reproductive phase – morpho – histo –chemical changes in shoot apex, floral meristems and floral development in *Arabidopsis* and *Antirrhinum*. **4L**
2. Development of stamen, anther, sporogenous tissue, microspores, pollen & male germ unit. **2L**
3. Development of Carpel, Ovule, Sporogenous tissue, megaspore, female gametophyte & female germ unit. **2L**
4. Double fertilization and triple fusion, interaction between pollen and gynaecial tissues, egg and sperm. **2L**
5. Zygote – ultrastructure, embryogenesis, patterns of embryo development **2L**
6. Endosperm- Ultrastructure, histochemistry and role in embryo development **1L**
7. Development and germination of seed
8. Developmental routes to Apomixis **2L**
9. Androgenesis and gynogenesis *in vivo* **1L**

Credit 3 –Molecular genetics of plant development **15L**

1. Techniques for studying development-specific gene expression. **2L**

Forward genetics: mutagenesis and screening, selecting, analyzing mutants.

Reverse genetics using T-DNA and transposons

2. Molecular genetics of :

(a) Embryogenesis, establishment of body plan **2L**

(b) Root, shoot and leaf development **2L**

(c) Transition to flowering and flower development **3L**

(d) Male and female gametophyte development, pollination and self-incompatibility **2L**

(f) Fertilization, imprinting and endosperm development **2L**

(g) Fruit and seed development, germination **2L**

Credit 4 - Intrinsic and extrinsic factors regulating plant development **15L**

1. Light mediated regulation–
   (a) Photoreceptors- phytochromes, cryptochromes, phytotropins **2L**
   (b) Signal transduction leading to photomorphogenesis and photoperiodic responses **4L**
   (c) Circadian rhythms **1L**
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 **5L**
   (b) Role of hormones in germination, growth and flowering. Cross-talk between hormone signaling pathways **2L**
3. Role of sugars and polyamines in regulating plant development **1L**

References

1. Bhojwani S. S. and Bhatnagar S. P. (1999). The embryology of angiosperms. Vikas Pub. House.
2. Bhojwani S.S. and Soh W.Y. (2001). Current Trends in Embryology of Angiosperms
3. Kluwer Academic Publishers.
4. Fahn A (1989) plant anatomy (Third edn) Pergamon Press
5. Gilbert (2006). Developmental biology (8th Edition). Sinauer Associates, Inc., Publishers, Sunderland, Massachusetts, USA.
6. Graham C.F. and Wareing P.F. (1984). Developmental Controls in Animals and Plants
7. Blackwell Scientific Publications
8. Jermy Burgess (1985) An Introduction to Plant Cell Development. Cambridge University Press
9. Johri B. M. and Srivastava P. S. (2001). Reproductive biology of plants. Narosa Pub. House, New Delhi.
10. Krishnamurthy K.V. (1988) Methods in Plant Histochemistry
11. Lewis Wolpert (2002), Principles of Development (2nd edition). Oxford University Press.
12. Lyndon R.F. (1990) Plant Development The Cellular Basis. UNWIN HYMAN
13. Raghavan V. (2000) Developmental Biology of Flowering Plants.Springer Verlag.
14. Razdan M.K. (2003) Plant Tissue Culture, Oxford IBH.
15. Wareing P. F. and Philips I. D. J. (1981) Growth and Differentiation in plants. Pergamon Press
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. Americal Society of Plant Physiology, Maryland

BO3.3 Plant Genetic Engineering - 4C

Credit 1 Recombinant DNA 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 **2L**
3. Use of vectors in cloning- Plasmids, phages, cosmids, phagemids, BACs and YACs **4L**
4. cDNA preparation and cloning **1L**
5. Polymerase chain reaction- Principles and uses in gene cloning **2L**

Credit 2 Gene libraries, screening of recombinants, sequencing

1. Genomic and cDNA libraries – choice of vectors, construction **4L**
2. Screening of libraries and isolation of specific clones- Nucleic acid hybridization using specific nucleotide probes, antibodies, PCR amplification using gene specific primers **6L**
3. DNA sequencing methods, sequencing strategies for large regions of DNA, contig maps and extension of maps by chromosome walking **5L**

Credit 3 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 **6L**
3. Transformation techniques: Agrobacterium-mediated, direct DNA transfer. Factors affecting transformation, screening for transformants **3L**
4. Handling transformants in subsequent generations **2L**

Credit 4 Applications of plant genetic engineering

1. Stress - Perception, signaling and stress-induced gene expression **3L**
2. Target genes for improving:
   a. Resistance against pathogens and pests – Case studies **3L**
   b. Abiotic stress tolerance – Case studies **3L**
3. Genetic engineering for production of food, biopharmaceuticals and other useful products – vaccines, antibodies, growth factors etc. Case studies **4L**
4. 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**

Practicals – BO 3.3 Plant Genetic engineering **1.5C = 6 practicals**

Any 6 practicals from the following

1. Transformation of *E.coli* with plasmid, selection of transformants by blue-white screening. **2P**
2. Transformation of *A. tumefaciens* with binary vector and selection for transformants. **2P**
3. Transformation of plant tissues using *Agrobacterium tumefaciens* based vectors. Detection of transformants using GUS assay **4P**
4. Transformation of plant tissues using *Agrobacterium rhizogenes* based vectors. Detection of transformants on the basis of hairy root formation **4P**

References

1. Recombinant DNA – Principles and Methodologies. Greene JJ and Rao VS, Marcel Dekker, New York, 1998.
2. Principles of gene manipulation and genomics. VIIth edition Primrose SB, Twyman RM, Blackwell Science, Oxford, 2006
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. Plant tissue culture, development and biotechnology, Trigiano R.N. and Gray, D.J. CRC Press, Taylor and Francis, Boca Raton, 2011

BO3.4 Quantitative methods and bioinformatics

Credit 1-Labmaths

Types of measurement and their units	**1L**
Making solutions – moles and molarity, stock solutions and dilutions, making media and reaction mixtures	**4L**
Ions and electrical potentials – Nerst and Goldman equations	**1L**
Osmolarity and osmotic pressure measurements	**1L**
Quantification of chemical reactions – equilibrium constant, reaction rates	**1L**
pH measurements and preparation of buffers	**2L**
Measuring concentrations using spectrophotometry	**1L**
Measurement of enzyme activity	**2L**
Specific activity of radioisotopes, making radioisotope solutions	**1L**
Cell counting using serial dilutions, haemocytometry	**1L**

Credit2 – Statistics 1

Populations and samples	**1L**
Data, graphical presentation of data – frequency distribution	**1L**
Mean, variance and standard deviation	**1L**
Sampling distributions, standard error of mean	**1L**
Normal (z) distribution, t distribution, confidence level	**3L**
Hypothesis testing and estimation, type I and type II errors	**4L**
Binomial and Poisson distribution	**2L**
Non-parametric tests	**2L**

Credit 3 – Statistics 2

Experimental designs- completely randomised, randomised block and factorial experimental designs	**4L**
Analysis of variance for different experimental designs, F distribution	**4L**
Correlation and regression, linear and non-linear regression, multiple regression	**4L**
Chi-square test for goodness of fit and independence	**4L**

Credit 4

Bioinformatics

Introduction to databases and retrieving information from databases:

Databases	**1L**
Molecular tools in protein and nucleotide sequence analysis; origin of new genes and Proteins, gene duplication and divergence	**3L**

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**
c. Protein structure prediction, motifs and domains **2L**

BO4.3 Biostatistics and Bioinformatics – 4C **(16 practicals)**

Biostatistics

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

Bioinformatics

Databases and database searching	**2P**
DNA and protein sequence comparisons:	
Pairwise comparison of DNA and protein sequences - BLAST	**2P**
Multiple sequence alignments, progressive methods, CLUSTAL	**2P**
Determining phylogenetic relationships using DNA and protein sequences	**2P**

Reference :

1. Lab Math – Adams, D.S. I.K. Internations Pvt Ltd. New Delhi, 2004

2. Statistical Methods – Snedecor G.W. and Cochran W.G. Affiliated East-West Press Pvt. Ltd. 1989

3. Statistical methods in Agriculture and Experimental Biology – Mead, R. and Curnow, R.N. Chapman and Hall, 1983

4. Practical statistics and experimental design for plant and crop science – Clewer, A.G. and Scarisbrick, A.H. , John Wiley, New York, 2001

5. Bioinformatics - Westhead, DR, Parish JH and Twyman, RM, BIOS Scientific Publishers Ltd., Oxford, 2003

6. Bioinformatics – Sequence and genome analysis. D.W. Mount, CBS Publishers, New Delhi, 2003

7. Bioinformatics and Molecular Evolution – Higgs PG and Attwood, TK

8. Blackwell Publishing, Oxford, UK, 2005

BO3.5 Practicals on BO3.1 and BO3.2 (5C)

Practicals on BO3.1 **(3C -any 12 Practicals)**

Tools of taxonomy – Types of tools, Field Tools, Laboratory Tools and Library Tools Taxonomic literature – Check lists, Floras, Keys, Monographs and Laboratory identification manuals.

Methods of field work, Non-destructive plant collection and documentation of the data, Maintaining field diary, Post-collection laboratory study of the plants, Herbarium preparation, Report writing, at least 3 local field visits. **(3P)**

For following practicals Bentham & Hooker's system should be used

*Comparative studies of families from at least three major groups (series of orders) of dicotyledons and two major groups of monocotyledons (diagnostic characters of the families as per Bentham and Hooker's system of classification) **(5P)**

*Identification of plants up to species giving reasons **(4P)**

*Preparation of artificial keys (for each key material from at least ten families) **(2P)**

Chemotaxonomy – Flower pigment analysis of plants from icoidales, Caryophyllales and Curvembryae. **(1P)**

Palynotaxonomy – Study of pollen characters of taxonomic significance **(1P)**
OR
Cytotaxonomy – Study of intergeneric / interspecific karyotypic differences. **(1P)**
* These exercises should cover in all at least 40 families.

Practicals on BO3.2 **(2C-Any 8 practicals)**

1. Isolation of shoot apical meristems from seedling, young and mature vegetative plant. **1P**
2. Tracing the course of stomatal development and observations on stomatal types. **1P**
3. Histochemical analysis of secondary growth (primary to secondary axis) **1P**
4. Histochemical comparison between vegetative SA and reproductively induced SA **1P**
5. Observations on **1P**
    a. microsporogenesis and development of male gametophyte (pollen)
    b. megasporogenesis and development of female gametophyte
6. Observations on types of endosperm, dissection and isolation of endosperm **1P**
7. Observations on stages of embryo development, dissection and isolation of developing embryo (3 stages) **1P**
8. *In vitro* germination of spore/pollen **1P**
9. Organogenesis in *in vitro* cultured tissues **2P**
10. Somatic embryogenesis in *in vitro* cultured tissues **2P**

BO3.6 Practicals on BO 3.3 and BO3.4 (5C)

Practicals on genetic engineering Any 8 practicals **(2C)**

1. Transformation of *E.coli* with plasmid, selection of transformants by blue-white screening. **2P**
2. Transformation of *A. tumefaciens* with binary vector and selection for transformants. **2P**
3. Transformation of plant tissues using *Agrobacterium tumefaciens* based vectors. Detection of transformants using GUS assay **4P**
4. Transformation of plant tissues using *Agrobacterium rhizogenes*. Detection of transformants on the basis of hairy root formation **4P**

Biostatistics Any 6 practicals **(1.5C)**

Data, graphical presentation of data – frequency distribution **1P**
Sample means and standard deviations, confidence intervals **1P**
Hypothesis testing-comparison of means **2P**
Analysis of variance **2P**
Correlation and regression **1P**

Bioinformatics Any 6 practicals **(1.5C)**

Databases and database searching **1P**
DNA and protein sequence comparisons:
Pairwise comparison of DNA and protein sequences - BLAST **2P**
Multiple sequence alignments, progressive methods, CLUSTAL **2P**
Determining phylogenetic relationships using DNA and protein sequences **2P**

Plant pathology B0: 4.1a

C 1 Plant diseases

1. Concept of disease, classification **(2L)**
2. Specific plant diseases, disease caused by fungi, symptoms, life cycles. **(3L)**
3. Diseases caused by bacteria and mollicutes. **(2L)**
3. Diseases caused by Viruses. **(2L)**
4. Disease caused by nematodes. **(2L)**
5. Plant disease epidemiology: Elements of an epidemic, patterns and comparison of epidemics development and forecasting plant disease epidemics. **(4L)**

C 2 Pathogens

1. Pathogenesis : Infection, reproduction and dissemination **(2L)**
2. Pathogen effects on photosynthesis, transpiration, respiration, growth **(4L)**
3. Enzymes and toxins in plant disease **(4L)**
4. Pathogenicity of biotrophic and necrotrophic pathogens **(5L)**

C 3 Host and resistance

Plant defenses: Non-host and host resistance, pre-existing and induced structural and chemical defenses **(8L)**

Molecular biology of host-pathogen interactions: Pathogenicity genes, avirulence genes, host R genes, effector molecules, miRNA **(7L)**

C 4 Disease management and control of diseases

Diagnostic methods for detecting pathogens **(2L)**
Breeding methods for improving resistance in plants **(3L)**
Control of disease using fungicides and other chemicals **(3L)**
Biocontrol agents for controlling disease **(3L)**
Disease control using biological and chemical activators of resistance **(3L)**

References:

1. Plant Pathology by R. S. Mehrotra, first edition, McGraw-Hill Education publication, 1982.
2. Plant Pathology by George N Agrios, fifth edition, Academic Press, London, 2005.
3. Plant Nematode: Morphology, Systematics, Biology and Ecology by M. R. Khan, first edition, Science Publishers, 2008.
4. Plant Pathogenesis and Resistance by Jeng-Sheng Huang, first edition, Springer Netherlands, 2001.
5. Plant Pathology by R. S. Mehrotra and Ashok Agarwal, second edition, Tata McGraw Hill Education, 2003.
6. Biocontrol of Plant Diseases by P. C. Trivedi, first edition, Aavishkar Publishers and Distributors, 2007.
7. Concise Encyclopedia of Plant pathology by P. Vidhyasekaran, first edition, CRC Press, 2004.
8. Topics in Mycology and Pathology by L. N. Nair, first edition, New Central Book Agency Kolkata, 2007.

BO 4.1b Plant diversity, Assessment and Conservation - 4 Credits

Credit 1 Introduction and Species diversity (15L)

1. Concept, definitions, scope and issues related to plant biodiversity. Taxonomic, ecological, and genetic perspective of plant biodiversity **2L**
2. Threats to Plant species diversity. **1L**
3. Magnitude and distribution of species diversity (Algae to Angiosperms) with special reference to India. **7L**
4. Ecogeographical pattern of distribution of species diversity, Phytogeographic and Floristic patterns of species diversity, Hotspots, plant diversity in Western Ghats, Eastern Himalayas, West coast and East coast **3L**
5. Centers of species diversity, Spatial patterns of species diversity, Endemism and species diversity, **2L**

Credit 2- Ecosystem and Genetic diversity (15 L)

1. Plant diversity within and between ecosystems with special reference to the following types of ecosystems in Indian sub content biomes. Freshwater, marine and terrestrial ecosystems, wetlands. **4L**
1. Causes of increase of ecosystem diversity. **1L**
2. Agro-biodiversity - Domestication and distribution of cultivated species with respect to agro climatic zones. Diversity in domesticated species. **2L**
3. Threats to Plant ecosystem diversity. **1L**
4. Genetic diversity Nature and origin of genetic variations (including molecular aspects), Genetic variation within and between populations, Measurement of Genetic diversity - Molecular approaches to plant diversity assessment based on allozymes and DNA based markers techniques **6L**
5. Threats to Plant genetic diversity. **1L**

Credit 3. Assessment of Plant biodiversity (15 L)

1. Methods of assessment of species diversity; Diversity indices – species richness, species abundance, and taxic diversity. **4L**
2. CAMP exercise - objectives and procedure, remote sensing and ground truthing, Inventorization & Monitoring **4L**
3. Measurement of ecosystem diversity. **2L**
4. Biodiversity Informatics: Management and Communication, Biodiversity information network , Databases, Metadata bases, Indian biodiversity portal **5L**

Credit 4- Conservation of Plant Biodiversity (15 L)

1. Conservation concept and need, categories of threatened plants, RET plants. Conservation of Species, Ecosystem and Genetic Diversity **2L**

2. **Strategies for plant conservation**
   Social Approach to Conservation: Sacred Groves, Sthalavrikshas, People's Movement for Biodiversity Conservation, Chipko Movement, Chico River Dam and Tribal Campaign **2L**

3. **Methods of conservation**
   In-situ and *ex-situ* Conservation
   In-situ Conservation: Introduction, Protected Areas:, Biosphere Reserves and National Parks, On-farm and Home Garden Conservation **4L**

4. **Ex-situ Conservation:** Germplasm Collections, Botanical Gardens, Seed Banks, Test-tube Gene Banks, Pollen Banks, Field Gene Banks, DNA Banks, *In-vitro* Conservation Methods, **6L**
5. Ecosystem Restoration **1L**

References:

1. Krishnamurthy K.V. (2003) An Advanced Textbook on Biodiversity-Principles and Practice, Oxford & IBH Publ. New Delhi
2. Michael J. Jeffries (2005) Biodiversity and Conservation, Routledge, London
3. William J. Sutherland (1997) Ecological Census Techniques – A Handbook. Cambridge Uni. Press.
4. Magurran Anne (1988) Ecological Diversity & Its Measurement, Chapman & Hall India
5. Uma Shaanker, R. Ganeshiah, KN. & Bawa KS (Eds) (2001) Forest Genetic Resources: Status, Threats and Conservation Strategies; Oxford & IBH, New Delhi
6. Heywood and Watson (Edt.) (1995) Global Biodiversity Assessment, UNEP, Cambridge University Press.
7. WCMC (1992) Global Biodiversity: Status of the Worlds Living Resources; Chapman and Hall, London
8. EDavid Hill, Matthew Fasham, Graham Tucker, Michael Shewry & Philip Shaw (Eds.) (2004) Handbook of Biodiversity Methods – Survey, Evaluation and Monitoring ; Cambridge
9. Handbook of the Convention on Biological Diversity (2001), Secretariat of the Convention on Biological Diversity. Earthscan publ., London
10. Avise JC (1994) Molecular Markers, Natural History and Evolution, Chapman & Hall, London

11. Barbier EB, Burgess JC & Folke C. (1994) Paradise Lost? The Ecological Economics of Biodiversity; Earthscan, London
12. Hajra P.K. & V. Mudgal (Eds.) (1997) Plant Diversity Hotspots in India – An Overview, BSI
13. John E. Weaver & F.E. Clement (1938) Plant Ecology. Mc Graw-Hill. NY.
14. Orians GH, Brown GM, Kunin WE & Swierbinski JE. (1990) Preservation and Valuation of Biological Resources; Univ. Washington Press
15. Bowles M.L. & Whelan C.J. (1996) Restoration of Endangered Species; Cambridge Univ. Press.
16. T.V. Ramchandra, R. kiran, N. Ahalya (2002) Status, Conservation & Management of Wetlands, Allied Publ. New Delhi.
17. Gadgil M. & Guha R. (1992) This Fissured Land: An Ecological History of India; Oxford University Press, New Delhi
18. Ashish Kothari (1997) Understanding Biodiversity- Life, sustainability and Equity; Orient Longman
19. N.K. Uberoi (2003) Environmental Management, Excel Books, New Delhi
20. Dwivedi O.P (1994), Environmental Ethics; Sanchar Publishing House, New Delhi
21. Bowles M.L. & Whelan C.J. (Eds.) (1996) Restoration of Endangered Species; Cambridge Univ. Press.
22. WRI/IUCN/UNEP (1992) Global Biodiversity Strategy: Guidelines for Action to Save, Study, and Use Earth's Biotic Wealth Sustainably and Equitably; WRI Publ, Baltimore, MD.
23. Shailaja Ravindranath & Sudha Premnath (1997) Biomass Studies – Field Methods for Monitoring Biomass, Oxford & IBH, New Delhi.
24. Michael P. (1984) Ecological Methods for field & Laboratory investigations, TMH Co. ltd. Bombay.
25. R. Bobbink, B. Beltman, J.T.A. Verhoeven and D.F. Whigham (Eds) (2006) Wetlands: Functioning, Biodiversity conservation, and Restoration, Springer, New York.
26. Ninan K.N. (2007) The Economics of Biodiversity Conservation, Earthscan, London
27. Singh J S, Singh S P and Gupta S R (2006) Ecology Environment and Resource Conservation, Anamaya Publishers

28. Paroda R S and Arora R K (1991) Plant Genetic Resources: Conservation and Management, IBPGR, India
29. Razdan M K and Cocking E C (1997) Conservation of Plant Genetic Resources *In Vitro*, Volume 1, Oxford & IBH Pub.
30. Foster, M. G. Mueller and Bills G. (2004) Biodiversity of fungi : Inventory and Monitoring methods Academic Press. 777ppp
31. Deshmukh S.K. and Rai M.K. (2005) The Biodiversity of Fungi Their role in Human life

Hunter –Cevera , J.C. and Angella Belt (1996) Maintaining cultures for Biotechnology and Industry.

BO 4.1c Clonal Propagation of Plants - (4C)

Credit 1:

Clonal Propagation: Overview of clonal propagation, advantages and limitations of clonal propagation. **1**

Methods of Vegetative propagation:

Cutting: Types, sources of cutting material, Rooting media, formula and carriers, disease control, environmental conditions for rooting, Hardening off and post production care. **2**

Grafting : Types, Seedling and clonal root stock system, formation of graft union, factors affecting graft union success, genetic limits of grafting, graft incompatibility, scion root stock relationship, After care of grafted plants. **3**

Budding: Types, Root stock for budding, time of budding **1**

Layering, Types, reasons for layering success, plant modification resulting in natural layering- tip layering, runners, stolons, offsets, suckers, crown. **2**

Propagation by specialized stem and roots- bulbs, corms, tubers, tuberous stem, tuberous root, rhizome, pseudobulb, management practices and handling. **2**

Vegetative propagation through seeds: Apomixis, Gametophytic Vs Sporophytic apomixis, Adventive embryony, Non recurrent apomixis, polyembryony, Vegetative apomixis, Diplospory and apospory, Significance of apomixis. **4**

Credit 2: Genetic improvement of clonally propagated plants

Genetic instability of clonally propagated plants, Phenotypic and genotypic variation within clones, somaclonal variation **5**

Artificial methods for induction of variation, Induced mutations by physical and chemical mutagens. **4**

Screening and propagation of variants, **3**

Breeding methods for improving vegetatively propagated plants **3**

Credit 3:

Basics of tissue culture: Tissue culture media, Plant Growth regulators, Aseptic techniques, laboratory equipments **3**

Micropropagation:

Stages of micropropagation Stage 0 –IV, Factors affecting micropropagation, **4**

Organogenesis-direct and indirect, Somatic embryogenesis- direct and indirect. **3**

Field trial of micropropagated plants **1**

Applications - Synthetic seed, microtuberization, Long term storage, cryopreservation of propagules, Virus free plants. **4**

Credit 4:

Case studies on micropropagation:

Methods and applications of micropropagation for:

a. cereals, **2**

b. pulses **2**

c. oilseeds **2**

d. ornamentals **2**

e. medicinal plants **3**

f. timber and fruit trees **4**

References:

1. Robert N. Trigiano & Dennis J. Gray 2011. "Plant tissue culture, Davelopment, and Biotechnology", CRC press, Taylor & Francis Group.

2. Caula A Beyl & Robert N. Trigiano 2008. Plant Propagation Concept & Laboratory Exercises, CRC press, Taylor & Francis Group.

3. Hudson T. Hartmann; Dale E. Kester; Fred T. Davies, Jr. & Robert L. Geneve 2007. Plant Propagation Principles and Practices, Seventh Edition, Prentice Hall of India Privet Limited, New Delhi.

4. K. Lindsey 2007. Plant Tissue Culture Manual Supplement 7, Springer India Private Limited, New Delhi, India.

5. G. A. Ravishankar, L. A. Venkataraman 1997, Recent Advances in Biotechnological Applications of Plant Tissue and Cell Culture. Oxford & IBH Publishing Co. Pvt. Ltd.New Delhi.

6. M. R. Ahuja 1993. Micropropagation of Woody Plants. Kluwer Academic publishers, AH Dordrecht, The Netherlands.

7. A. F. Mascarenhas 1993. Handbook of Plant Tissue culture. Indian Council of Agricultural Research, New Delhi.

8. M. K. Razdan 2003. Introduction to Plant TIssue Culture, second Edition. Oxford & IBH Publishing Co. Pvt. Ltd. New Delhi.

9. B.D. Singh

9. S.S. Bhojwani, M.K. Razdan 1996- Plant Tissue Culture: Theory and Practice, Elsevier Science

10. Jennie P. Mather, Penelope E. Roberts,(1998) "Introduction to Cell and Tissue Culture: Theory and Technique" Springer

11.Edwin F. George (2007). Plant Propagation by Tissue Culture: Volume 1.The background. Springer.

BO 4.1d- Plant –Organism Interactions

Credit 1:- Symbiotic associations

1. Lichens **(3L)**
2. Endophytic association of plants – algae, bacteria, fungi **(3L)**
3. Mycorrhizae **(4L)**
4. Nodulating bacteria **(4L)**

Credit 2- Herbivory and carnivorous plants

1. Herbivores – insects, grazing animals – physical and biochemical Interactions **(4L)**
2. Plant signaling and defense against herbivores **(4L)**
3. Genetic engineering in plants for improved tolerance against herbivores **(2L)**
4. Carnivorous plants – morphological features, specialized biochemical mechanisms for nutrient processing **(5L)**

Credit 3 – Plant –plant interactions

1. Allelopathy in plants **(6L)**
2. Parasitic plants **(3L)**
3. Competitive mechanisms in plants **(4L)**
4. Epiphytic plants **(2L)**

Credit 4 - Pollination and dispersal biology

1. Pollination mechanisms – flower structure with reference to pollination mechanisms, mimicry, thermogenesis **(3L)**
2. Pollinators – bees, beetles, butterflies, birds, mammals **(5L)**
3. Co-evolution of pollinators and plants, fig-fig wasps interaction, humming bird-plant interaction, etc **(3L)**
4. Seed dispersal mechanisms –fruit and seed morphology relevant to seed dispersal **(4L)**

References:

Walter Larcher 1995 “Physiological Plant Ecology”. 3rd Eds. Springer – Verlag New York Berlin Heidelberg

Zdenek Lastuvka, Barbara Politycka, S. S. Narwal, Jana Kalinova 2007, “Coactions and Competition in Higher Plants”, Scientific Publisher (India).

Malcolm C. Press, Jonathan D. Graves 1995, “Parasitic Plants”, Chapman & Hall, 2-6 Boundary Row, London.

Peter Scott 2008, “Physiology and Behaviour of Plants”. John Wiley & Sons Ltd.

BO 4.2a: Advanced Plant Physiology

BO 4.2a Optional Paper II: Advanced Plant Physiology

Credit 1: **(15 lectures)**

Properties of soil, absorption, transport and assimilation of water and minerals

Water and mineral utilization and conservation strategies in plants, evolution of biological nitrogen fixation

Leaf transpiration and stomatal physiology

Mechanism of biotic and abiotic stress tolerance

Credit 2: **(15 lectures)**

Evolution of photosynthetic systems

Mechanism of conversion of light energy to chemical energy

CO_2 concentrating mechanism and utilization of energy in carbon reactions

Spatial and temporal changes of photosynthesis in response to changing climate conditions

Biological function of photorespiration

Source and sink relationship

Credit 3: **(15 lectures)**

Organization and regulation of mitochondrial respiration in plants: relationship with biomass production, role in oxidative stress response, organ development in response to environmental stresses, Spatial and temporal changes of respiration in response to changing climate conditions

Influence of growth regulators in metabolism

Regulation of vegetative and reproductive growth

Credit 4: **(15 lectures)**

Physiology of *in vitro* grown structures and their applications

Spatial organization of enzymes in plant metabolic pathways

Modification of metabolic pathways

BO 4.3 Practicals on optional paper II **(Practicals)**

1. Induction of deficiency symptoms and growth analysis in crop plants (2)
2. Determination of activity of nitrate reductase and assimilation of nitrogen (1)
3. Study of transpiration and stomatal physiology under abiotic stress (1)
4. Determination of rate of photosynthesis using IRGA/Oxygen measurement system (1)
5. Study of activity of Rubisco and PEPcase enzyme (2)
6. Study of source and sink relationship in crop plants (1)
7. Study of effect of abiotic factors on photosynthesis (1)
8. Separation and identification of stress related proteins (1)
9. Study of respiration under stress condition using oxygen measurement system (1)
10. Effects of auxins and cytokinins or gibberellins on growth/enzyme activity (1)
11. Effect of nutrient constituents/growth regulators/environmental factors on growth and differentiation (1)
12. Development of biotic and abiotic stress tolerance using *in vitro* techniques (1)
13. Comparative physiological studies of control and transgenic plant (1)

References

1. Berg J.M., Tymoczko J.L., Stryrer 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. 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. Lowlor 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. Lincolin Taiz and Eduardo Zeiger (2010) Plant Physiology, Fifth edition. Sinauer Associates, Inc. Publishers. Sunder land, USA.

Periodicals and Journals

1. Current trends in Plant Sciences
2. Annual Review of Plant Physiology
3. Annual Review of Biology
4. Plant Cell
5. Plant Physiology
6. Journal of Plant Physiology
7. Physiologia Plantarum
8. Physiology and Molecular Biology of Plants
9. Indian Journal of Plant Physiology
10.Indian Journal of Biotechnology
11.Acta Physiologia Plantarum

BO 4.2bAdvanced angiosperm systematics and Evolution

Credit 1 **15L**

1. Angiosperm systematics – An overview **1L**
2. Evolution and diversity of Angiosperms - Fossil angiosperms and their ecology **6L**
3. Diversity and classification of Angiosperms – Recent systems **2L**
4. Introduction to APG III system of classification of angiosperms; characteristics and phylogeny of clades; (Magnoliids), Orders – Amborellales, Nymphaeales, Austrobaileyales, Chloranthales; (Commelenids), order Ceratophyllales, [eudicots - core eudicots rosids malvids, fabids asterids campanulids lamids.] **6L**

Credit 2 **15 L**

a. Phytochemistry as a source of data for systematics
b. Karyology as a source of data for systematics
c. Micromorphology as a source of data for systematic

Credit 3 **15L**

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

Credit 4 **15 L**

1. Biosystematics – aims, objectives, methodology. Biosystematic classification
2. Resources for Angiosperm systematic – Herbaria, Botanical gardens, Data information systems
3. Interrelation of systematic with other disciplines of plant sciences
4. Importance and applications of angiosperm systematic

References:

1. Agashe SN (1995) Paleobotany, Oxford and IBH Publ. Co. Pvt. Ltd, New Delhi.
2. Cronquist A J (1988). Evolution and Classification of Flowering Plants, 2nd edn, N Y Botanical Garden.
3. Davis P H and Heywood V H (1963). Principles of Angiosperm Taxonomy, Oliver and Boyd.
4. Eames A J (1961). Morphology of Angiosperms, McGraw Hill Book Co.

5. Erdtman G (1966). Pollen Morphology and Plant Taxonomy of Angiosperms (An introduction to Palynology I), Hafner Pub. Co. London.

6. Kubitzki K (1977). Flowering Plants Evolution and Classification of Higher Categories. Plant Systematics – Evolution Supplement I.

7. Kuijt J. (1969). The biology of parasitic flowering plants. California University Press.

8. Naik V N (1984). Taxonomy of Angiosperms, TMH, New Delhi.

9. Radford A E (1986). Fundamentals of Plant Systematics, Harper and Row N Y.

10. Singh G (2004). Plant Systematics, 2nd edn, Oxford and IBH, New Delhi.

11. Sivrajan V V (1984). Introduction to Principles of Plant Taxonomy, Oxford and IBH, New Delhi.

12. Smith P M (1976). The Chemotaxonomy of Plants, Edward Arnold Pub. Ltd.

13. Sporne K R (1974). Morphology of Angiosperms, Hutchinson University Library, London.

14. Stace C A (1989). Plant Taxonomy and Biosystematics.

15. Stewart W N and Rothwell G W (2005). Paleobotany and the Evolution of Plants, 2nd edn, Cambridge University Press.

16. Subrahmanyam K. Aquatic angiosperms. BSI. India

17. Cook T (1903). The Flora of Presidency of Bombay, Vol. I (Indian Reprint) Bishen Singh, Mahendra Pal Singh, Dehradun.

18. Cook T (1903). The Flora of Presidency of Bombay, Vol. II (Indian Reprint) Bishen Singh, Mahendra Pal Singh, Dehradun.

19. Hickey M and King C (2000). The Cambridge Illustrated Glossary of Botanical Terms. Cambridge University Press, UK.

20. Jain S. K. and Rao R. R. Handbook of Field and Herbarium Methods, Today and Tomorrow Publishers, New Delhi.

21. Jones S B and Luchinger A E (1986). Plant Systematics 2nd edn, McGraw Hill Book Co.

22. Lawrence G H M (1951). Taxonomy of Vascular Plants, Macmillan.

23. Mabberly T J (1997). The Plant Book 2nd edn Cambridge University Press, Cambridge.

24. Judd, Campbell, Kellogg, Stevens, Donoghue (2008) Plant Systematics A Phylogenetic Approach, 3rd edn Sunderland, Massachusetts USA

25. Michael G. Simpson (2006). Plant Systematics Dana Dreibelbis.

26. M. A. Geber, T. E. Dawson, L. F. Delph 1999 Gender and "Sexual Diamorphism in Flowering Plants".

27. David Winship Taylor, Leo J. Hickey 1996, "Flowering Plant Origin, Evolution & Phylogeny", Chapman & Hall New York.

28. Thomas J. Givnish, Kenneth J. Sytsma 1997, "Molecular Evolution and Adaptive Radiation". Cambridge University.

29. Douglas E. Soltis, Pamela S. Soltis, Peter K. Endress, Mark W. Chase, 2005, "Phylogeny and Evolution of Angiosperms". Sinauer Associates, INC. Sunderland Massachusettes.

BO 4.2C - Algology: Diversity and Applications of Algae (4 Credits, 2011-onwards)

Credit: 1

1. Algal Diversity and relationships: Importance of algal species identification, Problems in the identification of algal species, Alternative approach to algal identification, current trends in taxonomy. **(3L)**
2. Algae and their environments: Terrestrial; Freshwater; Marine and Estuarine, Algae in extreme environmental conditions, survival strategies, bioindicators, bloom forming algae, biofouling, algae and biotic associations, carbon sequestration. **(7L)**
3. Ecological classification of algae, algae of running water, intertidal algae. **(2L)**
4. Phytoplankton: Sampling, adaptation, primary productivity, periodicity, factors controlling phytoplankton populations. Calcification **(3L)**

Credit 2:

1. Taxonomy of Blue green algae: Botanical and Bacteriological Approaches; Chemotaxonomic studies: Lipid composition, Polyamines, Carotenoids and Biochemical features, phylogeny and evolution. **(3L)**
2. Systematics of the green algae: Introduction, Morphological, Ultrastructural and molecular (Phylogenetic) concepts, Green algal phylogeny and evolution. **(3L)**
3. Systematics of brown and red algae, histochemistry and evolution. **(3L)**
4. Microalgae: cultivation methods, role of nutrition: major and minor elements, scaling up, growth kinetics and measurements, harvesting, synchronous and continuous cultures.**(3L)**
5. Seaweed cultivation: Necessity, cultivation of *Porphyra*, *Eucheuma***,** *Gracilaria* and *Laminaria.* **(3L)**

Credit 3:

1. Algae as research tool, food and feed, fossil algae in paleoecological assessments, algae in space, animal aquaculture system, agriculture, waste water treatment, paper industry. Immobilization, cryopreservation. **(4L)**
2. Biofertilzers: Developments, Potentials of cyanobacterial biofertilzers, constraints, inoculums production, selection of carrier materials, selection and development of improved cyanobacterial inoculants. **(3L)**

3. Products and uses of microalgae: Vitamins and fine chemicals, single cell protein, pigments: β-carotene and phycobilioproteins**,** bioactive compounds**,** nutraceuticals and pharmaceuticals. **(4L)**
4. Algal lipids, polyunsaturated fatty acids and biofuel production. **(2L)**
5. Hydrogen and methane production from microalgae. **(2L)**

Credit: 4:

1. Commercially important seaweeds, their occurrence and utilization. **(1L)**
2. Seaweeds as a human diet-global Scenario, other uses of seaweeds. **(3L)**
3. Seaweed fertilizer in agriculture. **(1L)**
4. Production, properties and uses of agar-agar, alginic acid and carrageenan. **(5L)**
5. Phycoremediation of sewage, heavy metals and radionuclides. **(2L)**
6. Algal transgenics and biotechnology: production of transgenic algae, molecular farming, problems in the field of genetic engineering and biotechnology. **(3L)**

References:

1. Ahluwalia, A. S. (2003). (Ed.) *Phycology: Principles, processes and applications*. Daya Publishing House, New Delhi.
2. Andersen, R. A. (2005). Algal culturing techniques. Elsevier Academic Press, pp. 578.
3. Barsanti, L. and Gualitieri, P. (2006). *Algae: structure, anatomy, biochemistry and biotechnology*. Taylor & Francis, pp. 301.
4. Bellinger, E. G. and Sigee, D. C. (2010). *Freshwater algae: Identification and use as a bioindicators*. Wiley-BlackwelNJ, pp. 271.
5. Becker, E. W. (1994). Microalgae: biotechnology and microbiology. Cambridge University Press, pp. 293.
6. Borowitzka, M. A. and Borowitzka, L. J. (1988). (Ed.) *Microalgal Biotechnology*. Cambridge University Press, GB, pp. 477.
7. Bryant, D. A. (1994). (Ed.) *The molecular biology of Cyanobacteria*. Kluwer Academic Publishers, The Netherlands, pp. 881.
8. Chen, F. and Jiang, Y. (2001). (Ed.) *Algae and their biotechnological potential*. Kluwer Academic Publishers, The Netherlands, pp.306.
9. Dawson, E. Y. (1966). *Marine botany*. Holt, Reinehart and Winston, Inc., pp. 371.
10. Fogg, G. E., Stewart, W. D. P., Fay, P. and Walsby, A. E. (1974). T*he blue green algae.* Academic Press Inc. (London) Ltd. Pp. 459.
11. Grahm, L. E. and Wilcox, L. W. (2000). *Algae*. Prentice-Hall, Inc., NJ, pp. 640.

12. Gupta, R. K. and Pandey, V. D. (2007). (Ed.) *Advances in applied Phycology*. Daya Publishing House, New Delhi, pp. 305.
13. Hallmann, A. (2007). Algal transgenics and biotechnology. *Transgenic Plant Journal*, Vol: 1(1), 81-98.
14. Kaushik, B. D. (1987). *Laboratory methods for blue green algae*. Associated Publishing Company, New Delhi, pp. 171.
15. 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.
16. Kumar, H. D. (1999).*Introductory Phycology* (2nd Ed.). Affiliated East-West Press Pvt. Ltd., New Delhi, pp. 651.
17. Lee, R. E. (1999). (3rd Ed.) *Phycology*. Cambridge University Press, pp. 614.
18. Lobban, C. S. and Harrison, P. J. (1994). *Seaweed ecology and physiology*. Cambridge University Press, 367.
19. Round, F. E. (1984). *Ecology of algae*. Cambridge University Press, pp. 664.
20. Lobban, C. S. and Wynne, M. J. (1981). (Ed.) *The biology of seaweeds (Botanical monographs: volume-17)*. Blackwell Scientific Publications, pp. 786.
21. Seckbach, K. (2007). (ed.) *Algae and cyanobacterial in extreme environment*. Springer, The Netherlands, pp. 811.
22. Van Den Hoek, C., Mann, D. G. and Jahns, H. M. (1995). *Algae: An introduction to phycology*. Cambridge University Press, pp. 625.

B0 4.2d Diversity and application of fungi

Credit-1

1. Diversity of fungi in different habitats, ecosystem, industrial deposits **(7L)**
2. Diversity and antimicrobial activity of endophytic fungi. **(2L)**
3. Diversity ecology and conservation of fungi in forest. **(4L)**
4. Host-dependent species diversity. **(2L)**

Credit-2

1. Sources and pattern of diversity in plant pathogenic fungi. **(3L)**
2. Arbuscular mycorrhizal fungi diversity and abundance **(3L)**
3. Molecular characterization of Genetic diversity among AM fungi. **(3L)**
4. Diversity of fungi in mangrove ecosystem and acidic mine site **(4L)**
5. Diversity and abundance of nematode trapping fungi. **(2L)**

Credit-3

1. Fungi in relation to human activities: Beneficial and Harmful activities. **(3L)**
2. Utilization of fungi for production of metabolites: primary and secondary, Organic acids, enzymes, antibiotics and non- antibiotic therapeutics, ergot alkaloids, steroids, brewing industry, growth regulators, pigments. **(9L)**
3. Medicinal fungi. **(3L)**

Credit-4

1. Mushrooms and other edible fungi: nutritive and medicinal properties, toxic mushrooms, mycotoxins. **(4L)**
2. Lichens as sources of secondary metabolites and their applications, agricultural metabolites like mycoproteins, zearolone, gibberellins, aroma and flavoring compounds. **(6L)**
3. AM fungi and their application in forestry, agroforestry and restoration/ reclamation of waste land. **(5L)**

BO 4.3 Practicals on BO 4.2 d Mycology

1. Isolation of endophytic fungi and study of antimicrobial activity. **(2P)**
2. Isolation of fungi from different habitats and their culture **(1P)**
3. Determination of AM fungal diversity and abundance **(2P)**
4. Estimation of Ergosterol from filamentous fungi **(2P)**
5. Production and estimation of citric acid from *Aspergillus niger* **(2P)**
6. Quantitative estimation of Cellulases/ Pectinases from wood degrading fungi **(2P)**
7. Isolation and identification of lichen metabolites **(2P)**
8. Semiquantitative estimation of Mycotoxins **(1P)**
9. Production and estimation of Penicillin from *Penicillium chrysogenum* **(2P)**

References:

1. Introduction of Fungi by John Webster and Roland Weber, Third edition, Cambridge University Press, 2007.
2. Introductory Mycology by Alexopolous J., Mims C. W. and M. Blackwell, fourth edition, Wiley India Pvt Ltd, 2007.
3. Topics in Mycology and Pathology by L. N. Nair, first edition, New Central Book Agency Kolkata, 2007.
4. Fungal Biology by J. W. Deacon, forth edition, Blackwell Publishing Ltd, 2006.
5. Biodiversity of fungi: Inventory and Monitoring methods by M. S. Foster, G. F. Wills and J. M. Mueller, first edition, Academic Press, 2004.
6. Mycoremediation: Fungal Bioremediation by Harbhajan Singh, first edition, John Wiley and Sons, Hoboken, New Jersey, 2006.

BO 4.3 (PRACTICALS BASED ON BO 4.2C): (*Any 16*) **4 Credits**

1. Collection and identification of algae from diverse habitats. **(3P)**
2. Quantitative estimation of phytoplankton. **(1P)**
3. Study of tools in systematics of algae. **(2P)**
4. Culturing of algae: Isolation, purification and maintenance. **(3P)**
5. Quantitative and qualitative analysis of lipids. **(2P)**
6. Survey of algal products. **(1P)**
7. Phycoremediation of nutrients, salts and heavy metals. **(2P)**
8. Extraction and purification of agar-agar and alginates. **(3P)**
9. Algal growth measurements and growth curve studies. **(2P)**
10. Lyophilization of algae and testing for viability. **(2P)**
11. Determination of Carotenoids and phycobilioproteins. **(2P)**
12. Enrichment of algal cultures. **(1P)**
13. Immobilization of algae. **(1P)**
14. Bloom causing algae. **(1P)**
15. Control of algae. **(1P)**
16. Continuous culture of algae. **(1P)**
17. Preparation of seaweed liquid fertilizer. **(2P)**
18. Preparation of Single cell protein. **(1P)**

BO 4.2e PHARMACOGNOSY – Medicinal Plant Biology

CREDIT: 1

Introduction, definition, scope and importance of Pharmacognosy.

Analytical Pharmacognosy: Methods of standardization of drugs.

Evaluation of drugs –

Botanical Evaluation -Organoleptic (Macroscopic) evaluation and Microscopic evaluation.

Physical evaluation of drugs - Moisture content, viscosity, melting point, solubility, optical rotation, refractive index, percentage extractives, ash values and fluorescence analysis.

Phytochemical evaluation of drugs: Qualitative analysis and quantitative estimation. Occurrence, classification, general chemistry and properties of the followings- carbohydrates, proteins, lipids, fats, fixed oils, volatile oils, resins, alkaloids, glycosides, phenols, tannins and vitamins

Drug adulteration and storage of drugs.

Biological evaluation of drugs- biological and chemical assay of drugs

Role of chemotaxonomy and histochemistry in standardization of drugs.

CREDIT: 2

Detailed Pharmacognostic study of the following 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.

1. *Gelidium amanssi* Gaill.
2. *Ganoderma spp.*
3. Liverworts
4. *Dryopteris filix-mas* (L) Schott.
5. *Ephedra* sps.
6. *Aconitum napellus* Linn.
7. *Rauwolfia serpentina* Benth.
8. *Acorus calamus* Linn.
9. *Quassia amara* Linn.
10. *Cinchona* sps.

11. *Saraca asoka (*Roxb.) De Wild.
12. *Ocimum sanctum* Linn.
13. *Adhatoda vasica* Nees.
14. *Woodfordia floribunda* Salisb.
15. *Eugenia caryophyllata* Thumb.
16. *Coriandrum sativum* Linn.
17. Strychnos nux-vomica Linn.
18. Plantago ovata Forskal.

CREDIT: 3

Detailed Pharmacognostic study of the drugs obtained from following biological sources 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.

1. *Capsicum annuum* Linn.
2. *Asparagus racemosus* Willd.
3. *Aloe sps.*
4. *Withnia somnifera* Dunal.

Biogenesis of drugs, *In situ* and *Ex situ* conservation of medicinal plants and role played by different research institutes at National level, Biological assay of: - *Degitalis* and *Ephedra*, Chemical assay of: - *Nux - vomica* and Aconite.

CREDIT: 4

Basic principles of research and scope for medicinal plants in future

drug development.

Ethnobotany- its concept, relevance and classification of ethnobotany. Methods and techniques in ethnobotanical study. Role of Ethnobotany in medicinal plant research - contribution to modern medicine. Ethnopharmacology and its applications.

Forensic botany- Role of morphology, anatomy (quantitative microscopy) and narcotic and hallucinogenic drugs in forensic science Allergy and allergence.

Intellectual property right and Patent.

Introduction to Herbal Nutraceuticals and Cosmaceuticals

Botanical sources as a cosmaceuticals, properties and uses.

PRACTICALS BASED ON PHARMACOGNOSY SPECIAL PAPER 4C

Identification of drug with the help of Organoleptic and microscopic evaluation techniques…….....…….....…….... **2P.**

Percentage extractives and fluorescence analysis of drugs.. ....….. **1P.**

Determination of ash values of drugs…… **1P**

Histochemical studies of drugs.....……..... **1P.**

Chemotaxonomic studies of drug belonging to families – Meliaceae, Rutaceae and Simaroubaceae.....……..... **1P**.

Biological activity of chemical constituents of the drug/s…..…… **1P.**

Estimation of alkaloids from suitable medicinal plants…….…..... **1P.**

Estimation of glycosides from suitable medicinal plants....…… **1P**

Extraction of essential oils from suitable medicinal plants...…….. **1P**

Estimation of Oleo resin from suitable medicinal plants ...…… **1P**

Preparation of Herbal foods ……. **1P**

Preparation of herbal cosmetics …….. **1P**

Visit to Pharmaceutical industries for studying methodology and

field visit to study ethnobotany and reporting……. **1P**

1. Visit to Pharmaceutical industries to be arranged.

2. At least one short and one long study tour be arranged for collection of medicinal plants and to explore ethno botanical data. Student must submit the tour report and ethno botanical data during practical examination.

3. Student must carry out detailed Pharmacognostic investigation of at least one drug and should submit at the time of practical examination as a project.

REFERENCES - FOR PHARMACOGNOSY SPECIAL PAPER I , II AND III.

1. Allport, N. L. 1943, Chemistry and Pharmacy of Vegetable drugs.
2. Anonymous, 1955, Pharmacopoeia of India, Manager Publications, New Delhi.
3. Anonymous, 1968, British Pharmacopoeia, GMC Press, London.
4. Bhavprakash and Sarangdhar Sanhita
5. Bonner James, 1950, Plant Biochemistry.
6. Charka Sanhita
7. Chopra, R.N. , 1933, Indigenous Drugs of India, The Art Press, Calcutta.
8. Chopra, R.N.; Chopra, I.C.; Handa, S.L. and Kapoor, L. D. 1958, Indigenous Drugs of India, U. N. Dhur and Sons Pvt. Ltd. Calcutta.
9. Daniel, M and Sabnis, S. P. 1990, A Phytochemical approach to Economic Botany, Kalyani Prakashan, Ludhiana.
10. Daniel, M. 1991, Methods in Plant Chemistry and Economic Botany, Kalyani Prakashan, Ludhiana.
11. Das and Bhattacharya, 1995, Pharmacognosy, Churchill Livingstone Ltd. New Delhi.
12. Datta, S.C. and Mukerji, B. 1950, Pharmacognosy Of Indian Root and Rhizome Drugs, Government Publications, India.
13. Dymok, W.; Warden, C.J. H. and Hooper, D. 1890, Pharmacographia Indica, Vol. I – III, Periodical Press, Delhi.
14. Gokhale, S. B., 1979, Textbook of Pharmacognosy, Jai Publishing House, Jalgaon.
15. Gokhale, S.B.; Kokate, C. K. and Purohit, A.P. 1996, Textbook of Pharmacognosy, Nirali Prakashan, Pune.
16. Goodman and Gilman, 1991, Pharmacological Basis of Therapeutic, Mac Millam Press, Singapore.
17. Goodwin, T.W., 1972, Introduction To Plant Biochemistry
18. Harborne, J.B. 1977 – Methods in Phytochemistry3rd edition
19. Harris Cosmaceuticology
20. Indian Journal Of Pharmaceutical science.
21. Indian Drugs. May 2000
22. Iyangar, M. A. 1974, Pharmacognosy of Powdered Drugs, Manipal, India.
23. Iyangar, M. A. and Naik, G. K. 1994, Anatomy of Crude Drugs, Manipal, India.

24. Jain, S. K., 1991, Contribution to Indian Ethnobotany, Scientific Publisher, 5/ A, New Delhi.
25. Journal of Ethnopharmacology, Elseiver Scientific Publisher, Ireland.
26. Journal of Economic and Taxonomic Plants, Jodhpur
27. Journal of Medicinal and Aromatic Plants Lucknow.
28. Journal of Pharmacology.
23. Kaiyadeo Nighantu
24. Khandalwal, K.I. 1998, Practical Pharmacognosy, Nirali Prakashan, Pune.
25. Kirtikar, K. R. and Basu, B.D., 1933, Indian Medicinal Plants, Parabasi Press, Calcutta.
26. Krishnamurthy, K. V., 1988, Methods In Plant Histochemistry.
27. Lawrence and Banner, 1996, Pharmacology, Longman Publishing New Delhi.
28. Nadkarni, A. K. 1972, Indian Material Medica, Popular Book Depot, Bombay.
29. Patwardhan, B. and Ranade, V. 1992, Handbook of Research Methods, Amol Prakashan, Pune.
30. Plumer, D. T., 1978, An Introduction to Practical Biochemistry, Tata Mac Grew hills Publishing Co. Ltd. Bombay.
31. Ramavat, K. G., 2003, Plant Biotechnology, S. Chand And Co. Ltd..
32. Ramstad, E., 1959, Modern Pharmacology.
33. Rasheeduz, Zafar, 1996, Medicinal Plants of India, CBS Publishers and Distributors, Delhi.
34. Reinhold, L. and Liwischitz, Y. 1968, Progress In Phytochemistry, Interscience Publisher, London.
35. Sadasivam, S. and Manickam, A.1996, Biochemical Methods, New Age International Publishers, New Delhi.
36. Shah, C.S. and Quadri, J.S. 1990, Textbook of Pharmacognosy, B.S. Shah Prakashan, Ahmedabad.
37. Smith, P. M. - Chemotaxonomy Of Plants.
38. Swain, T. E., 1966, Chemical Plant Taxonomy, Academic Press, London and New York.
39. Tayler, V.E.; Brady, L.R. and Robber, J. R. 1976, Pharmacognosy, Balliere Tindall, Calcutta.
40. Trease and Evans, 1972, Pharmacognosy, Lea and Fobiger, Philadelphia.

41. Wagner, H. 1984, Plant Drug Analysis.
42. Wagner, H., 1977, New Natural Products and Plant Drugs with Pharmacological, Biological or Therapeutical Activity.
43. Wallis, T. E., 1967, Practical Pharmacology.
44. Wallis, T.E. 1967 Textbook of Pharmacognosy, J and A Churchill LTD, London.

BO4.2f – Optional paper Plant Biotechnology

Credit 1 - Plant genome and proteome

1. Gene and whole genome sequencing strategies, deep sequencing **5L**
2. Fundamental gene set, evolution and elaboration of plant genomes – whole genome duplication and divergence, lineage-specific variation, synteny **4L**
3. Genomic databases and their application in comparison of genomes **3L**
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.
5. Studying protein-DNA and protein-protein interactions – Chromatin immunoprecipitation assays, gel mobility shift assays, yeast 2-hybrid system, affinity chromatography, GST-pull down etc **3L**

Credit 2- Gene expression

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 **5L**

2. Gene-tagging and plasmid rescue, promoter and enhancer traps **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 **5L**

Credit 3 – Secondary metabolite production in plant cultures

1. Types of culture systems used for secondary metabolite production **3L**
2. Improving secondary metabolite production in culture **6L**
   a. Regulation of secondary metabolite pathways and compartmentalization
   b. Manipulation of nutrient media, precursor additions
   c. Immobilization of cells
   d. Elicitation using biotic and abiotic elicitors
   e. Biotransformation
   f. Screening and selection of high secondary metabolite producing cell lines.
5. Bioreactors- Types of bioreactors, growth, product analysis and scaling up **3L**
6. Pathway engineering - Enhancing secondary metabolite production through genetic manipulation of biosynthetic pathways **3L**

Credit 4 - Molecular markers and their applications

1. DNA based markers: **7L**
   DNA polymorphism studies using hybridization-based techniques and PCR based techniques – RAPD, AFLP, SSR polymorphisms, microsatellite-primed PCR, sequence-based polymorphism
2. Applications of molecular markers: **8L**
   Diversity studies, DNA fingerprinting, population structure studies, phylogenetic relationships - distance based, maximum likelihood, maximum parsimony methods, genetic mapping, QTL mapping, map based cloning. Software used for these applications

BO4.3 - Practicals on BO4.2f Plant Biotechnology 4C = 16P

Any 16 practicals of the following

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. Immobilization of cells and comparative analysis of secondary metabolite production in immobilized and suspension cultures. **3P**
6. Manipulating cultures using elicitors for enhanced production of secondary metabolites **3P**
7. 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**

References:

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

BO: 4.2g Advanced Plant Genetics and Breeding

Credit 1: Cytogenetics:

Chromosome markers, banding, genetic maps, cytogenetic maps and physical maps, GISH and FISH analysis. **4**

Chromosome pairing , meiotic and breeding behaviour, their consequences and application of : Haploids, autopolyploids, allopolyploids, segmental polyploids, synthetic polyploids **3**

Aneuploids (Nullisomics, monosomics, trisomics, tetrasomics).Mapping methods with aneuploids, alien addition / substitution lines. **3**

Chromosomal aberrations: Deletion, duplication and translocation. Mapping using deletion lines **3**

Apomixis: Genetics of apomictic systems & its application. **2**

Credit 2: Special approaches for Crop improvement

Breeding methods for self, cross and vegetatively propagated crops. **4**

Distant hybridization in plant breeding: Barriers for the production of distant hybrids, Technique, sterility in distant hybrids and its application in crop improvements. **2**

Hybrid varieties: Development and evaluation of inbreeds, production of hybrid seeds, merits, demerits and achievements through hybrid varieties. **3**

Chromosomal manipulations for crop improvement – transfer of whole genome, chromosome, chromosome segment, **2**

Concept of Ideotype in crop improvement. **1**

Release of New varieties and quality seed classes, production practices and maintenance **2**

Breeder and Intellectual Property Rights(IPR). **1**

Credit 3: Molecular markers and its applications.

Molecular markers: Different types of molecular markers, genome analysis , Mapping populations, Gene Mapping with molecular markers, Map based cloning, QTL identification and mapping. **8**

Marker assisted selection (MAS): MAS in Gene pyramiding and backcross breeding. **3**

Use of MAS for QTL and disease resistance. **4**

Credit 4: Breeding methodology in selected Crops

Breeding for resistance to Abiotic stresses, Biotic stresses, Quality- Protein and oil. **5**

Case Studies:

Breeding strategies (conventional & biotechnological approach) for improvement of following crops: **10**

Rice

Wheat

Pigeon pea

Cotton

Mustard

Practical (4 credit) any 16 practicles

Analysis of induced aberration (Maize)	**3**
Meiotic behaviour of auto and allopolyploid.	**2**
Analysis of chiasma frequency.	**2**
Karyotype analysis through slide preparation.	**3**
Handling data on polygenic traits for analysis of variance and covariance, partitioning of variance components, heterosis.	**2**
Analysis of interspecific hybrids	**3**
Chromosome banding.	**3**
Detection of alien chromatin in interspecific hybrids using *in situ* hybridization.	**4**
Study of genomic behaviour in interspecific hybrids by meiotic analysis.	**2**
Biochemical analysis of segregating population or mutant for protein and oil quality.	**3**
Analyzing data for quantitative traits (Partitioning of genotypic and environmental components, heritability, prediction of combining ability, heterosis and inbreeding)	**2**
Testing segregating population / mutant against biotic or abiotic stress.	**2**
Use of ISSR/RAPD markers for assessing genetic diversity in genetic resources.	**4**

References:

1. Atherly, A.G., Girton, J.R. and Mcdonald, J. F. (1999) The science of genetics. Sauders College Pub. Fort Worth USA.

2. Burnham, C.R. (1962) Discussions in cytogenetics. Burgess Pub. Co., Minnesota.
3. Hartl, D.L., Jones E.W.(2001). Genetics: Principle and analysis (4th edn) Jones and Barlett Pub., USA.

4. Khush, G S (1973) Cytogenetics of Aneuploids. Academic press New York, London.

5. Lewin, B. Genes VIII. Oxford, University press. New York, USA.

6. Russel, P.J. 1998. Genetics (5th edn). The Benjamin/ Cummins Pub. Co., Inc. USA.

7. Snustad, D.P. and Simmons, M.J. ,2000. Principles of genetics (4th edn). John Wiley and Sons, Inc., USA.

8. David Freifelder, Microbial Genetics

9. Strickberger, M.W: Genetics (4th edn). Mcmillan Publishing Company, New York.

10. Griffiths, A.J.F and Gilbert, W.M (2nd edn). Modern genetic analysis. W.H. Freeman and Company, New york.

11. Singh, B.D.(2005). Plant breeding: principles and methods. 7th edn.

12. Allard, R.W.(1960), principles of plant breeding. John Wiley and sons, Inc., New York.

13. Chopra, V.L. (2000) Plant breeding: Theory and practice 2nd edn. Oxford & IBH Pub., Co., ltd. New Delhi.

14. Jain, H.K. and Kharwal, M.C.(2003) Plant breeding: Mendelian to molecular Approaches. Navrosa Publishing House Pvt. Ltd., New Delhi.

15. Mandal, A.K. Ganguli, P.K., Banergee, S.P. 1991. Advances in Plant breeding. Vol 1 and 2, CBS Pub. & distributors.

16. Sharma, J.R. 1994. Principles and practices of plant breeding. Tata Mcgraw Hill. Pub. Co. Ltd. New Delhi.

17. Simmonds, N.W. 1979 Principles of crop improvement. Longman, London and New York.

18. VL Chopra, Plant Breeding: Theory & Practice.

19. D.Roy, Plant Breeding: Analysis & exploitation of variation. Narosa publication.

20. DK Kar & S. Haldar, Plant Breeding & Biometery.

21. S.K. Gupta, Plant Breeding: Theory & Techniques, Agrobios Publications.

22. VL Chopra, editor, Breeding Field Crops, Oxford &IBH Pub.

BO 4.2 h: Advanced Environmental Botany

Credit 1: Conservation Biology

1. *In situ* and *ex situ* conservation strategies. 3L
2. Deforestation and aforestation, social forestry and agro forestry 4L
3. Environmental legislation in India: Environment protection Act 4L
4. Various conventions and their protection and conservation: Reviews of various national and international obligations in the environmental protection such as CITIES, RAMSAR, Montreal, Basal, CBD etc 4L

Credit 2: Environmental Impact Assessment

1. Environmental pollution types and sources of pollution 2L
2. Pollution monitoring: Physical, chemical and biological parameters used. Various biological indices including algal indices, Process of bioaccumulation and biomagnifications 4L
3. Threats to the earth: Global warming, Ozone layer depletion, natural Calamities 4L
4. Koyoto protocol, CDM, Carbon sequestration, clean technology and its importance, concept and role of green belt 5L

Credit 3: Environmental Biotechnology

1. Waste treatment: biological methods used in treatment of sewage. 3L
2. Sludge treatment and its application 3L
3. Phytoremediation: Concept, process and application in decontaminating soils and water 4L
4. Genetic improvement for bioremediation 2L
5. Designing bioremediation protocol 3L

Credit 4: Sustainable Development

1. Renewable energy resources: solar energy, geothermal energy, wind energy, wave energy, tidal energy, hydroelectric energy and energy from biomass 3L
2. Non renewable energy resources: fossil fuels such as coal and natural gas 2L
3. Nuclear fuel 1L
4. Sustainability of wetland and forests 3L
5. Sustainable agriculture 3L
6. Urban planning and sustainable cities 2L

References

1. Begon, M., Townsend, c. R., Harper, J. L. (2005). Ecology: From individuals to Ecosystems, 4th edition, Wiley-Blackwell.
2. Odum, E. P. (2007) Fundamentals of Ecology , 5th edition, Thomson books.
3. Coleman, D.C., Crossley, D. A., Handrix, P. F (2004) Fundamentals of Soil Ecology, 2nd edition, Elsevier academic press.
4. Ambhast, R. S. (1988) A Text Book Of Plant Ecology, 9th edition, Friends and Co.
   Canter L (1996) Environmental Impact Assessment, 2nd Edition, McGraw Hill Publishing Company.
5. Coller, B. D., Cox, G.W., and Miller, P. C. (1973). Dynamic ecology, Prentice-Hall, Inc. Englewood Cliffs, New Jersey
6. De, A. K. (1994) environmental chemistry, Wiley Eastern publication
7. Gurevitch, J., Scheiner, S. M., Fox, G. A. (2006) The ecology of plants, Sinauer Associates.
8. Hynes, H. B. N. (1978) Biology of polluted water, 1st edition, Liverpool University Press
9. Kershaw, K. A. (1978) Quantitative and dynamic plant ecology, 2nd edition, Edward Arnold publication
10. Kumar, H. D. (1981) Modern concepts of ecology, (8th edition), Vikas publication
11. Barbour, M.G., Pits, W.D., and Burk, J. H. (1967) Terrestrial Plant Ecology, Addison-Wesley Publisher.
12. Crawley, M., Crawley, J., Crawley, M. (1997) Plant ecology, 2nd edition, Wiley-Blackwell.
13. Mishra, R. (1968) The Ecology Work Book, Oxford and IBH public. Co., Kolkata.
14. Mukherjee, B. (2000) environmental management: Basic and applied aspects of management of ecological environmental system, 1st edition, Vikas Publication House.
15. Mukherjee, B. (1996) Environmental Biology, 1st edition, Tata Mcgraw Hill.
16. Odum, E. P. (2007) Fundamentals of ecology, 5th edition, Thomson books.
17. Stern, A. C. (1970) Air Pollution, volume 1, 2nd edition, academic press.
18. Yadav, P. R., and Mishra, S. R. (2004) Environmental biology, Discovery publication, New Delhi.

Practicals (4 Credits) (16 Practicals)

1. Studying pollution indicator plants in terms of morphology and anatomy **2P**
2. Comparison of stomatal index from polluted and non polluted areas **1P**
3. Comparison of pollen fertility from polluted and non polluted areas **1P**
4. Studying the effect of radiation on plants **2P**
5. Estimation of CO_2, DO, chlorides, alkalinity and BOD of the water samples **2P**
6. Exercise on carbon sequestration **2P**
7. Studying plant community using transect method **1P**
8. Interpretation of aerial photographs of vegetation **1P**
9. Treatment of wastes by microbes and plants **2P**
10. Visit to the site of social forestry/Agroforestry/water treatment plants. **2P**

BO 4.3 Practicals on optional paper II
(4C =16 Practicals)

BO4.3 - Practicals on BO4.2a Advanced Plant Physiology

1. Induction of deficiency symptoms and growth analysis in crop plants **(2)**
2. Determination of activity of nitrate reductase and assimilation of nitrogen **(1)**
3. Study of transpiration and stomatal physiology under abiotic stress **(1)**
4. Determination of rate of photosynthesis using IRGA/Oxygen measurement system **(1)**
5. Study of activity of Rubisco and PEPcase enzyme **(2)**
6. Study of source and sink relationship in crop plants **(1)**
7. Study of effect of abiotic factors on photosynthesis **(1)**
8. Separation and identification of stress related proteins **(1)**
9. Study of respiration under stress condition using oxygen measurement system **(1)**
10. Effects of auxins and cytokinins or gibberellins on growth/enzyme activity **(1)**
11. Effect of nutrient constituents/growth regulators/environmental factors on growth and differentiation **(1)**
12. Development of biotic and abiotic stress tolerance using *in vitro* techniques **(1)**
13. Comparative physiological studies of control and transgenic plant **(1)**

BO4.3 - Practicals on BO4.2b Advanced Angiosperm systematics and evolution

1. Chemotaxonomy **4P**
2. Cytotaxonomy **4P**
3. Palynotaxonomy **4P**
4. Molecular taxonomy **4P**

BO4.3 - Practicals on BO4.2c Advanced algology

1. Collection and identification of algae from diverse habitats. **(3P)**
2. Quantitative estimation of phytoplankton. **(1P)**
3. Study of tools in systematics of algae. **(2P)**
4. Culturing of algae: Isolation, purification and maintenance. **(3P)**
5. Quantitative and qualitative analysis of lipids. **(2P)**
6. Survey of algal products. **(1P)**
7. Phycoremediation of nutrients, salts and heavy metals. **(2P)**
8. Extraction and purification of agar-agar and alginates. **(3P)**
9. Algal growth measurements and growth curve studies. **(2P)**
10. Lyophilization of algae and testing for viability. **(2P)**
11. Determination of Carotenoids and phycobilioproteins. **(2P)**
12. Enrichment of algal cultures. **(1P)**
13. Immobilization of algae. **(1P)**
14. Bloom causing algae. **(1P)**

15. Control of algae. **(1P)**
16. Continuous culture of algae. **(1P)**
17. Preparation of seaweed liquid fertilizer. **(2P)**
18. Preparation of Single cell protein. **(1P)**

BO4.3 Practicals on BO 4.2d Mycology

1. Isolation of endophytic fungi and study of antimicrobial activity. **(2P)**
2. Isolation of fungi from different habitats and their culture **(1P)**
3. Determination of AM fungal diversity and abundance **(2P)**
4. Estimation of Ergosterol from filamentous fungi **(2P)**
5. Production and estimation of citric acid from *Aspergillus niger* **(2P)**
6. Quantitative estimation of Cellulases/ Pectinases from wood degrading fungi **(2P)**
7. Isolation and identification of lichen metabolites **(2P)**
8. Semiquantitative estimation of Mycotoxins **(1P)**
9. Production and estimation of Penicillin from *Penicillium chrysogenum* **(2P)**

BO4.3 - Practicals on BO4.2e Pharmacognosy – Medicinal plant biology

Identification of drug with the help of Organoleptic and microscopic evaluation techniques **2P**
Percentage extractives and fluorescence analysis of drugs.. ....….. **1P**
Determination of ash values of drugs…… **1P**
Histochemical studies of drugs.....……..... **1P**
Chemotaxonomic studies of drug belonging to families – Meliaceae, Rutaceae and Simaroubaceae.....……..... **1P**
Biological activity of chemical constituents of the drug/s…..…… **1P**
Estimation of alkaloids from suitable medicinal plants…….... **1P**
Estimation of glycosides from suitable medicinal plants....…… **1P**
Extraction of essential oils from suitable medicinal plants**...……..** **1P**
Estimation of Oleo resin from suitable medicinal plants ...…… **1P**
Preparation of Herbal foods ……. **1P**
Preparation of herbal cosmetics …….. **1P**
Visit to Pharmaceutical industries for studying methodology and field visit to study ethnobotany and reporting……. **1P**

1. Visit to Pharmaceutical industries to be arranged.

2. At least one short and one long study tour be arranged for collection of medicinal plants and to explore ethno botanical data. Student must submit the tour report and ethno botanical data during practical examination.

3. Student must carry out detailed Pharmacognostic investigation of at least one drug and should submit at the time of practical examination as a project.

BO4.3 - Practicals on BO4.2f Plant Biotechnology

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. Immobilization of cells and comparative analysis of secondary metabolite production in immobilized and suspension cultures. **3P**
6. Manipulating cultures using elicitors for enhanced production of secondary metabolites **3P**
7. 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**

BO4.3 - Practicals on BO4.2g Advanced genetics and plant breeding

1. Analysis of induced aberration (Maize) **3**
2. Meiotic behaviour of auto and allopolyploid. **2**
3. Analysis of chiasma frequency. **2**
4. Karyotype analysis through slide preparation. **3**
5. Handling data on polygenic traits for analysis of variance and covariance, partitioning of variance components, heterosis. **2**
6. Analysis of interspecific hybrids **3**
7. Chromosome banding. **3**
8. Detection of alien chromatin in interspecific hybrids using *in situ* hybridization. **4**
9. Study of genomic behaviour in interspecific hybrids by meiotic analysis. **2**
10. Biochemical analysis of segregating population or mutant for protein and oil quality.**3**
11. Analyzing data for quantitative traits (Partitioning of genotypic and environmental components, heritability, prediction of combining ability, heterosis and inbreeding **2**
12. Testing segregating population / mutant against biotic or abiotic stress**.** **2**

    Use of ISSR/RAPD markers for assessing genetic diversity in genetic resources. **4**

BO4.3- Practicals on BO4.2h Advanced environmental botany

1. Studying pollution indicator plants in terms of morphology and anatomy **2P**
2. Comparison of stomatal index from polluted and non polluted areas **1P**
3. Comparison of pollen fertility from polluted and non polluted areas **1P**
4. Studying the effect of radiation on plants **2P**
5. Estimation of CO_2, DO, chlorides, alkalinity and BOD of the water samples **2P**
6. Exercise on carbon sequestration **2P**
7. Studying plant community using transect method **1P**
8. Interpretation of aerial photographs of vegetation **1P**
9. Treatment of wastes by microbes and plants **2P**
10. Visit to the site of social forestry/Agroforestry/water treatment plants. **2P**