

SRIDEV SUMAN UTTARAKHAND UNIVERSITY, BADSHAHITHAUL, TEHRI  
GARHWAL  
SYLLABUS: BOTANY COURSE FOR M.Sc. STUDENTS (4 SEMESTERS)

OBJECTIVES OF THE COURSE

To teach the fundamental concepts of Botany and their applications, the syllabus pertaining to M.Sc. (2 Year Degree Course) in the subject of Botany has been prepared as per provision of UGC module and the demand of the academic environment. The syllabus contents are duly arranged unit-wise and contents are included in such a manner that due importance is given to requisite intellectual and laboratory skill. The M.Sc. course of Botany consists of 2 year course with semester system - in all 4 semesters (Two semesters in each year).

Total Marks : 2000 (1000 per year and 500 per semester) of core and elective disciplines

M.Sc. Semester I

Paper No.	Title	Paper Code	Max. Marks (100)	
			Ext.	Int.
I	Microbiology (Bacteria, Viruses and Lichens)	BOT101	80	20
II	Mycology and Plant Pathology	BOT102	80	20
III	Phycology and Bryology	BOT103	80	20
IV	Pteridophyta, Gymnosperms and Palaeobotany	BOT104	80	20
	Lab Course	BOT10P	80	20

M.Sc. Semester II

Paper No.	Title	Paper Code	Max. Marks (100)	
			Ext.	Int.
I	Taxonomy of Angiosperms	BOT201	80	20
II	Cytogenetics and Molecular Biology	BOT202	80	20
III	Economic Botany	BOT203	80	20
IV	Plant Morphology, Anatomy and Embryology	BOT204	80	20
	Lab Course	BOT20P	80	20

M.Sc. Semester III

Paper No.	Title	Paper Code	Max. Marks (100)	
			Ext.	Int.
I	Plant Physiology and Biochemistry	BOT301	80	20
II	Plant Ecology and Remote Sensing	BOT302	80	20
III	Plant Biotechnology	BOT303	80	20
IV	Elective (Any one of the following) (a) Plant Health Management (b) Diversity and Cultivation of	BOT304/EI	80	20

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	Mushrooms (c) Applied Plant Anatomy (d) Ecosystem Analysis, GIS and Remote Sensing (e) Environmental Management with Reference to Western Himalaya.	BOT304/E2 BOT304/E3 BOT305/E4 BOT305/E5		
	Lab Course	BOT30P	80	20

#### M.Sc. Semester IV

Paper No.	Title	Paper Code	Max. Marks (100)	
			Ext.	Int.
I	Plant Breeding and Biostatistics	BOT401	80	20
II	Conservation Biology	BOT402	80	20
III	In-vitro Technologies and Industrial Applications	BOT403	80	20
IV	Elective Paper(Any one of the following) (a) Forest Ecology (b) Industrial Microbiology (c) Ethnobotany (d) Palynology and pollination Biology (e) Seed Pathology	BOT404/E1 BOT404/E2 BOT404/E3 BOT404/E4 BOT404/E5	80	20
	Lab Course	BOT40P	80	20

### SYLLABUS

#### SEMESTER I

##### Paper I (BOT101): Microbiology (Bacteria, Viruses and Lichens)

###### Unit 1:

1. General account of Microorganisms: History of microbiology, classification of microorganisms- five kingdom classification, characteristic features of bacteria and actinomycetes.

2. Culture Study of Microorganisms: Methods of isolation and culture of microorganisms; measurement of microbial growth; microbial genetics.

###### Unit 2:

1. Morphology and structure of Bacterial cells: Morphology of Bacterial cells based on size, shape and arrangement, fine structure of bacterial cells (of both Gram-negative and Gram-positive Bacteria) - capsule cell wall, cell appendages (flagella, fimbriae and pili).

2. Structure of plasma membrane, cytoplasmic inclusions- mesosomes, chlorosome.

###### Unit 3:

1. Morphology and structure of viruses: History, morphology, fine structure, shape and classification of viruses.

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2. Microplages and Prions; Tobacco mosaic virus (TMV), T<sub>4</sub>.
3. Bacteriophage and HIV- their fine structure, genome organization and multiplication, bacteriophage therapy.

#### Unit 4

1. Role of microorganism; Root nodules, *nif* gene organization; role of microorganisms in soil (decomposition and nutrient cycling), water and air; role in industry- production of antibiotics, bio-fertilizers and bio-pesticides.
2. General account of lichens: Occurrence, classification, morphology, anatomy, reproduction and their importance.

#### SUGGESTED READINGS:

1. Doelle, H.W. and C.G. Heden 1986. Applied Microbiology, Kluwer Academic Press, London.
2. Pelczar, M.J., Chan, ECS and Kreig, N.R. 1993, Microbiology, Concept and Applications. Mc Graw Hill, New York.
3. Ross, F.C. 1983. Introductory Microbiology. Charles E. Merrill. Publ. Co. Columbus, Ohio.
4. Alexander, M. 1991. Microbial Ecology. John Wiley and Sons, New York.
5. APHA. 1971. Standard Methods for the Examination of water and Waste Water. Washington DC
6. Atlas, R. M. Principle of Microbiology.
7. Board, R.G. and D.W., Lovelock 1975. Some Method for Microbiological Assay. Academic Press, New York
8. Casida, L.E. 1968. Industrial Microbiology. John Wiley and Sons, New York.
9. Clifford, H.T. and W. Stephenson 1975. An Introduction to Numerical Classification, Academic press, New York.
10. Doelle, H.W. and C.G., Heden 1986. Applied Microbiology. Kluwer Acad. Press, London.
11. Kaushik, P. 1996. Introductory Microbiology. Emkay Publ, Delhi.
12. Miller, B.M. and W. Litsky 1976. Industrial Microbiology. Mc Graw Hill New York.
13. Mukherjee, K.G. and Ved Pal Singh, 1997. Frontiers in Applied Microbiology. Rastogi Publ. Meerut.
14. Norris, J.R. and D.W. Ribbons 1970. Methods in Microbiology. Academic Press, London.
15. Power, C.B. and H.F. Duginawala 1996. General Microbiology 2 Vols. Himalaya Pub. House, New Delhi.
16. Ross, F.C. 1983. Introductory Microbiology. Charles E. Merrill Publ. Co. Columbus, Ohio.

#### Paper II (BOT102): Mycology and Plant Pathology

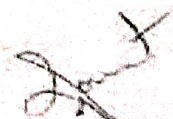

##### MYCOLOGY

###### Unit 1

1. History of Mycology; India and abroad.
2. General characters of Fungi; Substrate relationship in fungi; Cell ultra-structure; unicellular and multicellular organization, nutrition (saprobic, biotrophic, symbiotic); reproduction (vegetative, asexual, sexual).
3. Recent trends in the classification.

###### Unit 2

1. Phylogeny of Fungi; General account of *Mastigomycotina*, *Zygomycotina*, *Ascomycotina*, *Basidiomycotina*, *Deuteromycotina*; Fungi in industry, medicine and as food.
2. Mycorrhizae; Fungi as bio-control agents.



3. Symptoms, causal organisms of plant pathogens belonging to various fungal classes i.e. *Mastigomycotina*, *Zygomycotina*, *Acomycotina*, *Basidiomycotina* and *Deuteromycotina*.

#### PLANT PATHOLOGY

##### Unit 3

1. History of plant pathology in India; Losses caused by pathogens and pests; types of pathogens; symptoms of different diseases.
2. Plant-microbe interaction: pathogenesis: prepenetration, penetration and post penetration events, and factors affecting disease development (host factors, environmental factors, virulence and susceptibility).
3. Dissemination of pathogens: Means of dissemination (active and passive dissemination)

##### Unit 4

1. Disease control: Cultural practices, chemical methods (insecticides, systemic and nonsystemic chemical), biological control: introduction, biological control of insects and pests, use of resistant varieties, integrated management for disease control, quarantine.
2. Brief account, structure, importance, disease cycle and control of the following:  
(i) Damping off, (ii) Wilt, (iii) Root rot, stem rot and fruit rot, (iv) Mildews (powdery and downy), (v) Rusts, (vi) Smuts, (vii) Leaf spots and leaf blights.
3. General characteristics, importance, disease cycle and control of the following:  
(i) Bacterial disease, (ii) viral disease, (iii) mycoplasma disease, (iv) phytoplasma disease.

#### SUGGESTED READINGS:

1. Ainsworth, G.C. 1971. Ainsworth and Bisby's Dictionary of Genera of Fungi. Central Myco. Inst. Kew. Surrey.UK.
2. Alexopoulos, C.J., Mims, C.W. and Blackwell, M. 1996. Introductory Mycology. John Wiley & Sons Inc.
3. Bilgrami, K.S. 1982. Physiology of Fungi. Bishen Singh Mahendrapal Singh, Dehradun.
4. Clifton, A. 1958. Introduction to the Bacteria. McGraw-Hill book Co., New York.
5. Mandahar, C.L. 1978. Introduction to Plant Viruses. Chand & Co. Ltd., Delhi.
6. Mehrotra, R.S. and Anuja, R.S. 1998. An Introduction to Mycology. New Age Intermediate Press.
7. Webster, J. 1985. Introduction to Fungi. Cambridge University Press.

#### Paper III (BOT103): Phycology and Bryology

##### PHYCOLOGY

##### Unit 1

1. Algal habitats.
2. Thallus organization, cell structure and reproduction (vegetative, asexual and sexual).
3. Algal Classification, Criteria for classification of algae: pigments, reserve food and flagella.
4. Phylogeny and interrelationships of algae.

##### Unit 2

1. Classification and salient features of Chlorophyta, Charophyta, Xanthophyta, Bacillariophyta, Phaeophyta, Rhodophyta and Cyanophyta.
2. A knowledge of algal life cycles; alternation of generations in algae; cytology and sexuality; physiology and biochemistry of algae; nitrogen fixation; parasitic algae.

3. Economic importance of Algae, Algal blooms, algal biofertilizers, algae as food and feed; uses of algae in industry.

#### BRYOLOGY

##### Unit 3

1. Morphology, structure reproduction and life history.
2. Classification and Phylogeny of various groups.
3. General account of Marchantiales, Jungermanniales, Calobryales, Sphaerocarpaceae, and Anthocerotales.

##### Unit 4

1. General account of Sphagnales, Andreales, Funariales, and Polytrichales.
2. Knowledge of the distribution of bryophytes in the Himalaya.
3. Ecology of bryophytes, their association with other organisms.
4. Fossil bryophytes: General account.

#### SUGGESTED READINGS:

1. Cavers, F. 1979. The Interrelationships of the Bryophytes Reprint. Bishen Singh Mahendrapal Singh, Dehradun.
2. Fritsch, F.E. 1979. The Structure and Reproduction of Algae. Reprint. Bishen Singh Mahendrapal Singh, Dehradun.
3. Kashyap, S.R. 1968. Liverworts of the Western Himalayas and Punjab Plains. The Chronica Botanic Co. Delhi.
4. Kumar, H.D. 1988. Introductory Phycology. Affiliated East-West Press Ltd., New Delhi.
5. Morris, I. 1986. An Introduction to the Algae. Cambridge University Press, U.K.
6. Parihar, N.S. 1991. Bryophyta. Central Book Depot, Allahabad.
7. Prescott, G.W. Algae: A Review. Bishen Singh Mahendrapal Singh.
8. Puri, P. 1980. Bryophytes. Atma Ram & Sons, Delhi.
9. Ram Udar. Fifty years of Bryology in India. Golden Jubilee Series. IBS, New Delhi.
10. Round, F.E. 1986. The Biology of Algae. Cambridge University Press, Cambridge.
11. Smith, G.M. 1955. Cryptogamic Botany. Vol. I and II. Tata Mc Graw Hill, New Delhi.
12. Stewart, W.N. and Rathwell, G.W. 1993. Paleobotany and the Evolution of Plants. Cambridge University Press.

#### Paper IV (BOT104): Pteridophyta, Gymnosperms and Palaeobotany

##### PTERIDOPHYTA

##### Unit 1

1. History, origin, classification, present and past distribution, morphology and life history of the following types.
  - a. Psilophyta: Psilophytales (*Psilophyton*) and Psilotales (*Psilotum*).
  - b. Lycophyta: Lepidodendrales (*Lepidodendron*), Lycopodiales (*Phylloglossum*), Lepidospermales (*Lepidocarpon*) and Isoetales (*Isoetes*).
  - c. Sphenophyta: Salient features of order Hymeniales, Sphenophyllales and Calamitales.
  - d. Pterophyta: A general account of Ophioglossales, Osmundales, Filicales, and Salviniales.

##### GYMNOSPERMS

##### Unit 2

1. Classification and distribution of Gymnosperms in India with special reference to Himalaya.
2. Study of morphology, structure and life-history as illustrated by the following and indicated in the practical work:

Pteridospermales: Palaeozoic and Mesozoic groups with references to Lyginopteridaceae (*Lyginopteris*) and Medullosaceae (*Trigonocarpus*), A general account of Glossopteridaceae.

3. Bennettitales: A general account of Cycadeoidaceae, Williamsoniaceae and Wielandiellaceae.

#### Unit 3

1. Cycadales: A detailed account including distribution of living Cycads.

2. A general account of Pentoxylales and Cordaitales.

3. Ginkgoales: *Ginkgo*.

4. A general account of fossil and living Coniferales and Taxales.

5. Ephedrales, Welwitschiales and Gnetales: A general account.

6. Economic importance of Gymnosperms.

#### PALAEOBOTANY

#### Unit 4

1. Definition of fossil, different types of plant fossils as per their mode of preservation, concept of form genus.

2. Indian Gondwana Sequence, a general account.

3. Introductory idea of Continental Drift Hypothesis.

#### SUGGESTED READINGS:

1. Andrews, H.N. 1961. Studies in Palaeobotany. New York.

2. Baker, J.G. 1995. Handbook of the Fern Allies. Reprint. Bishen Singh Mahendra Pal Singh, Dehradun.

3. Bhatnagar, S.P. and Mitra, A. 1996. Gymnosperms. New Age International Pvt. Ltd., New Delhi.

4. Beddome, R.H. 1966. The Ferns of British India. 2 Vols. Oxford and IBH, New Delhi.

5. Chamberlain, C.J. 1955. Gymnosperms: Structure and Evolution. Chicago.

6. Eams, A.J. 1969. Morphology of Lower Vascular Plants.

7. Parihar, N.S. 1996. Biology & Morphology of Pteridophytes. Central Book Depot Allahabad.

8. Raizada, M.B and Sahni, K.C. 1958. Living Indian Gymnosperms.

9. Sahni, K.C. 1996. Gymnosperms of India and Adjacent Countries. Bishen Singh Mahendrapal Singh, Dehradun.

10. Seward, A.C. 1919. Fossil Plants for Students of Botany and Geology. 4 Vols. Cambridge.

11. Sporne, K.R. 1991. The Morphology of Pteridophytes, Hutchinson Library Series London.

#### Lab Course (BOT10P):

1. Study of representative genera of Zygomycotina, Ascomycotina, Basidiomycotina and Deuteromycotina.

2. Symptomatology of at least one diseased specimen of plant pathogens belonging to various fungal classes i.e. *Mastigomycotina*, *Zygomycotina*, *Ascomycotina*, *Basidiomycotina* and *Deuteromycotina*, bacteria and viruses.

3. Aseptic methods and demonstration of instruments viz., autoclave, hot air oven, incubator, laminar air flow.

4. Direct examination of root nodule bacteria under microscope and isolation of *Rhizobium* in root nodules.

5. Isolation and enumeration of microbes from natural samples (soil and water) by agar plate technique.

6. Morphological study of representative members of algae: *Microcystis*, *Lyngbya*.

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*Cylindrospermum, Gloeotrichia, Scytonema, Pandorina, Eudorina, Scenedesmus, Pediastrum, Hydrodictyon, Ulva, Enteromorpha, Draparnaldiopsis, Stigeoclonium, Fritschella, Coleochaete, Bulbochaete, Cosmarium, Caulerpa, Nitella, Dictyota, Gelidium, Gracillaria, Batrachospermum and Polysiphonia.*

7. Study and identification with suitable preparations of *Ricciocarpus, Targionia, Cyathodium, Plagiochasma, Asterella (Fimbriaria), Dumortiera, Sewardiella, Pellia, Fossombronia, Porella, Calobryum, Notothylas, Sphagnum, Polytrichum* and *Funaria*.

8. *Psilotum, Isoetes, Ophioglossum, Osmunda, Polypodium, Azolla, Salvinia* and important fossil types.

9. *Cycas, Ginkgo, Abies, Cedrus, Cryptomeria, Cupressus, Podocarpus, Cephalotaxis, Araucaria, Taxus, and Gnetum*

10. Study of available fossil flora through specimens and slides, etc.

## SEMESTER II

### Paper I (BOT201): Taxonomy of Angiosperms

#### Unit 1

1. Origin of intra-population variation: Population and the environment; ecads and ecotypes; evolution and differentiation of species- various models.

2. The species concepts; taxonomic hierarchy; species, genus, family and other categories; principles used in assessing relationship, delimitation of taxa and attribution of rank.

#### Unit 2

3. Salient features of the International Code of Nomenclature for Algae, Fungi and Plants (ICN)

4. Taxonomic evidences and Taxonomic tools: anatomy, palynology, embryology, phytochemistry, histological, cytological, phytochemical, serological, biochemical and molecular techniques.

#### Unit 3

5. Systems of angiosperm classification: Phenetic versus phylogenetic systems; cladistics in taxonomy; major systems of classification (Bentham and Hooker, Hutchinson, Cronquist) and their relative merits and demerits.

6. Herbaria and Botanical gardens: General account.

7. Plant exploration in India with reference to North-West Himalaya.

8. Status of flowering plant diversity in Garhwal Himalaya.

#### Unit 4

Distinguishing features and economic importance of Dicot families of

- (i) Polypetalae- Magnoliaceae, Violaceae, Linaceae, Rutaceae, Rhamnaceae, Sapindaceae, Anacardiaceae, Myrtaceae.
- (ii) Gamopetalae- Dipterocarpaceae, Ericaceae, Oleaceae, Rubiaceae, Asteraceae, Acanthaceae.
- (iii) Monochlamydeae- Chenopodiaceae, Amaranthaceae, Urticaceae.
- (iv) Monocots- Orchidaceae, Arecaceae, Liliaceae, Amaryllidaceae, Zingiberaceae, Dioscoreaceae, Cyperaceae, Poaceae.

### SUGGESTED READINGS

1. Babu, C.R. 1976. Herbaceous Flora of Dehradun, CSIR, New Delhi.
2. Cole, A.J. 1969. Numerical Taxonomy, Academic Press, London.

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3. Cronquist, A. 1981. An Integrated System of Classification of Flowering Plants. Columbia University Press, New York.
4. Davis, P.H. and Heywood, V.H. 1973. Principles of angiosperms Taxonomy. Robert E. Kreiger Pub. Co., New York.
5. Gaur, R.D. 1999. Flora of District Garhwal: NW Himalaya, Transmedia, Srinagar, Garhwal.
6. Grant, V. 1971. Plant Speciation. Columbia University Press, New York.
7. Grant, W.F. 1984. Plant Biosystematics. Academic Press, London.
8. Harrison, H.J. 1971. New Concepts in Flowering Plant Taxonomy. Hieman Educational Books Ltd., London.
9. Heywood, V.H. and Moore, D.M. 1984. Current Concepts in Plant Taxonomy. Academic Press, London.
10. Hutchinson, J. 1973. The Families of Flowering Plants: 2 Vols. Oxford University Press, Oxford.
11. Jain, S.K. and Rao, R.R. 1977. A handbook of Field and Herbarium methods. Today and Tomorrow, New Delhi.
12. Jones, A.D. and Wilbins, A.D. 1971. Variations and Adaptations in Plant Species. Hieman & Co. Educational Books Ltd., London.
13. Jones, S.B., Jr. and Luchsinger, A.E. 1986. Plant Systematic (2nd edition). McGraw- Hill Book Co., New York.
14. Lawrence, H.W. 1951. Taxonomy of Vascular Plants. Reprint Oxford and IBH, New Delhi.
15. Naithani, B.D. 1985. Flora of Chamoli. 2 Vols, BSI, Calcutta. Nordenstam, B., El Gazaly, G. and Kassar, M. 2000. Plant Systematic for 21st Century. Portland Press Ltd., London.
16. Radford, A.E. 1986. Fundamentals of Plant Systematics. Harper & Row Publications, USA.
17. Singh, H. 1978. Embryology of Gymnosperms. Encyclopaedia of Plant Anatomy X. Gebruder Borntraeger, Berlin.

## **Paper II (BOT202): Cytogenetics and Molecular Biology**

### **Unit 1**

1. The dynamic cell: Structural organization of the plant cell; specialized plant cell.
2. Cell wall: structure and functions; biogenesis, growth.
3. Plasma membrane: structure, models and functions; sites for ATPases, ion carriers, channels and pumps, receptors.
4. Mitochondria and chloroplast: Structure, genome organization, gene expression.

### **Unit 2**

1. Nucleus: structure, nuclear pores, nucleosome organization.
2. Ribosomes: Structure, cytoprotein synthesis.
3. Chromatin organization: Chromosome structure and packaging of DNA, molecular organization of centromere and telomere, euchromatin and heterochromatin, specialized types of chromosomes; polytene, lampbrush, B-chromosomes and sex chromosomes.

### **Unit 3**

1. Principles of inheritance: Mendelian laws along with molecular explanations, Exceptions to Mendelian laws, lethal alleles and Gene Interactions.
2. Structural and numerical alterations in chromosomes: Origin, occurrence, production and meiosis of haploids, aneuploids and euploids, induction and characterization of trisomies and monosomies.

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3. Genetics of prokaryotes and eukaryotic organelles: genetic recombination of phage; genetic transportation, conjugation and transduction in bacteria, cytoplasmic male sterility.

#### Unit 4

1. Gene structure and expression: Genetic fine structure, cis-trans test; fine structure analysis of eukaryotes, introns and their significance, regulation of gene expression in prokaryotes and eukaryotes, DNA damage and repair mechanism, defects in DNA repair, Initiation of cancer at cellular level, proto-oncogenes and oncogenes.

2. Genetic recombination and genetic mapping: Recombination; independent assortment and crossing over, linkage groups, genetic markers, construction of molecular maps.

3. Mutations: Spontaneous and induced mutations; physical and chemical mutation, molecular basis of gene mutation; mutations induced by transposons.

4. Nuclear DNA content; C-value paradox; Cot curves.

#### SUGGESTED READINGS:

1. Alberts, B., Bray, D., Lewis, J., Raff, M., Roberts, K. and Watson, J.D. 1989. Molecular Biology of the Cell (2nd edition), Garland Publishing Inc., New York.
2. Atherly, A.G., Girton, J.R. and McDonald, J.F. 1999. The Science of Genetics, Saunders College Publishing, Fort Worth, USA.
3. Burnham, C.R. 1962. Discussions in Cytogenetics, Burgess Publishing Co., Minnesota.
4. Busch, H. and Rothblum, L. 1982. Volume X. The Cell Nucleus rDNA Part A. Academic Press.
5. Barry, J.M. and Barry, B.M. 1973. Molecular Biology, Prentice Hall Of India New Delhi.
6. Buchanan, B.B., Gruissem, W. and Jones, R.L. 2000. Biochemistry and Molecular Biology of Plants, American Society of Plant Physiologists, Maryland, USA.
7. De, D.N. 2000. Plant Cell Vacuoles: An Introduction, CSIRO Publication, Collingwood, Australia.
8. Gupta, P.K. 1998. Cytogenetics, Rastogi Publications, Meerut.
9. Hartl, D.L. and Jones, E.W. 1998. Genetics: Principles and Analysis (4th edition), Jones & Bartlett Publishers, Massachusetts, USA.
10. Kleinsmith, L.J. and Kish, V.M. 1995. Principles of cell and Molecular Biology (2nd Edition), Harper Collins College Publishers, New York, USA.
11. Krishnamurthy, K.V. 2000. Methods in Cell wall Cytochemistry, CRC Press, Boca Raton, Florida.
12. Lewin, B. 2000. Genes VII, Oxford University Press, New York.
13. Lodish, H., Berk, A., Zipursky, S.L., Matsudaira, P., Baltimore, D. and Darnell, J. 2000. Molecular Cell Biology (4th Edition), W.H. Freeman and Co., New York, USA.
14. Malacinski, G.M. and Freifelder, D. 1998. Essentials of Molecular Biology (3rd edition), Jones and Bartlett Publishers, Inc., London.

#### Paper III (BOT203): Economic Botany ECONOMIC BOTANY

##### Unit 1

1. Plant resources: Concept, status, utilization and concerns.
2. World Centers of Primary Diversity of domesticated plants

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3. Origin, evolution, botany, cultivation, cytotaxonomy and uses of (i) Cereals and millets (wheat, paddy, maize), (ii) Legumes (soybean, black gram and cowpeas), (iii) Sugar cane and starches (sugarcane, beetroot, potato, sweet potato, cassava), (iv) Forage and fodder crops.

#### Unit 2

1. Fiber crops, medicinal and aromatic.  
2. Important firewood and timber yielding plants and non-wood forest products (NWFPs) such as bamboos, gums, tannins, dyes, resins, beverages.

#### INTELLECTUAL PROPERTY RIGHTS

#### Unit 3

1. Intellectual Property Rights, Concept, History, Protection of IPR;  
2. Patent- requirements, procedures and limitations; International convention on Biological Diversity.

#### ETHNOBOTANY

#### Unit 4

1. Concept, linkage with other sciences, tools of ethnobotanical studies, world and Indian perspective with special reference to the Himalayas.  
2. Green revolution: Benefits and adverse consequences.  
3. Plants used as ornamentals and avenue trees.  
4. Principles of conservation: Extinction; Status of plants based on International Union for Conservation of Nature (IUCN).

#### SUGGESTED READINGS:

1. Ayensu, E.S., Heywood, V.H. and Lucas G.L.: 1984. Our green and living world: The wisdom to save it. Cambridge Univ. Press. Cambridge.
2. Baenzinger, S.P., Kleese, R.A. and Barns, R.F. 1993. Intellectual Property Rights, Protection of plant materials; executive summary and work group reports. CSSA Publication No. 21. Crop Science Soc. of America, Wisconsin, Madison.
3. Bellamy, R. 1993. Ethnobotany in Tropical forests: expedition in field techniques, Royal Geographic Society of London.
4. Berlin, B. 1992. Ethnobiological Classification: Principles and categorization of plants and animals in traditional societies. Princeton Univ. Press. Princeton.
5. Chandl. K.P.S., Shukla, G. and Sharma, N. 1996. Biodiversity in Medicinal and Aromatic Plants in India: Conservation and Utilization. National Bureau of Plant Genetic Resources, New Delhi.
6. Conway, G. and Barbier, E. 1994. Plants, Genes and Agriculture. Jones and Bartlett Publishers, Boston.
7. Council of Scientific & Industrial Research 1986. The Useful Plants of India. Publications and Information Directorate, CSIR, New Delhi.
8. Council of Scientific & Industrial Research (1948-1976). The Wealth of India: A Dictionary of Indian Raw Materials and Industrial Products. New Delhi. Raw Materials I-XII, Revised Volume I-III (1985-1992) Supplement (2000).
9. Densmore, F. 1974. How Indians use wild plants for food, medicine and crafts, Dover Publication Inc. New York.
10. WWF INDIA 1993. Directory of Indian Wetlands, New Delhi and AWB, Kuala Lumpur.
11. Falk, D.A., Olwell, M. and Millan, C. 1996. Restoring Diversity. Island Press, Columbia, USA.
12. Frankel, O.H., Brown, A.H.D. & Burdon, J.J. 1995. The Conservation of Plant Diversity.

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Cambridge University Press, Cambridge, U.K.

13. Gadgil, M. and Guha, R. 1996. Ecology and Equity: Use and Abuse of Nature in Contemporary India. Penguin, New Delhi.
14. Gangulee, P. 1998. Gearing up for patents- the Indians Scenario. Univ. Press. Hyderabad.
15. Hill, A.F. 1952. Economic Botany. McGraw Hill., New York.
16. Kochar, S.L. 1998. Economic Botany in the Tropics. Mac Millan India Ltd. Delhi
17. Kothari, A. 1997. Understanding Biodiversity: Life Sustainability and Equity. Orient Longman.
18. Kohli, R., Arya, K.S., Singh, P.H. and Dhillon, H.S. 1994. Tree Directory of Chandigarh. Lovedale Educational, New Delhi.
19. Nair, M.N.B. *et al.* (Eds) 1998. Sustainable Management of Non-Wood forest Products. Faculty of Forestry, Universiti Putra Malaysia. 434004 PM Serdang, Selangor, Malaysia
20. Paroda, R.S. and Arora, R.K. 1991. Plant Genetic resources conservation and Management. IPGRI (Publication) South Asia Office, C/o NBPGR, Pusa Campus, New Delhi.
21. Rodgers, N.A. and Panwar, H.S. 1988. Planning a Wildlife Protected Area Network in India. Vol. 1. The Report. Wildlife Institute of India, Dehradun.
22. Sahni, K.C. 2000. The Book of Indian Trees, 2nd edition. Oxford University Press Mumbai.
23. Sharma, O.P. 1996. Hill's economic Botany (Lata Dr. A.F. Hill, adapted by O.P. Sharma). Tata McGraw Hill Co. Ltd., new Delhi.
24. Swaminathan, M.S. and Kocchar, S.L. (Eds.) 1989. Plants and Society. Macmillan Publication Ltd., London.
25. Thakur, R.S., Puri, H.S. and Husain, A. 1989. Major Medicinal Plants of India. Central Institute of Medicinal and Aromatic Plants, CSIR, Lucknow.
26. Walter, K.S. and Gillet, H.J. 1998. IUCN Red List of Threatened Plants. IUCN The World Conservation Union. IUCN, Gland, Switzerland, and Cambridge, U.K.

#### **Paper IV (BOT204): Plant Morphology, Anatomy and Embryology**

##### **PLANT MORPHOLOGY**

###### **Unit 1**

1. Shoot Development: Organization of the shoot apical meristem (SAM); control of cell division and tissue differentiation especially xylem and phloem; secretory ducts and laticifers; wood development in relation to environmental factors and wood anatomy. Leaf growth and differentiation (structural development and classification of stomata and trichomes).
2. Root development: Organisation of root apical meristem (RAM); vascular tissue differentiation; lateral roots; root hairs.
3. Morphology of flower, stamen and carpel. Plant adaptations and their morphological nature.

##### **EMBRYOLOGY**

###### **Unit 2**

1. Male gametophyte: Structure of anther, microsporogenesis; pollen germination, pollen allergy; pollen embryos.
2. Female gametophyte: Ovule development; megasporogenesis; development and organization of the embryo sac.
3. Pollination, Pollen-pistil interaction and fertilization: Floral characteristics, pollination mechanism and vectors; commercial consideration: structure of the pistil; pollen stigma interactions, sporophytic and gametophytic self-incompatibility (cytological, biochemical and molecular aspects); double fertilization; in vitro fertilization.

###### **Unit 3**

1. Seed development and fruit growth: Endosperm development during early, maturation and desiccation stages; embryogenesis, cell lineages during late embryo development.
2. Polyembryony; apomixis, embryo culture.
3. Latent Life-dormancy: Importance and types of dormancy; bud dormancy.

#### ANATOMY

##### Unit 4

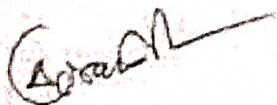
1. Tissue - General account
2. Stem anatomy - Dicot and Monocot
3. Root anatomy - Dicot and Monocot
4. Anamolous Secondary Growth - *Boerhaavia*, *Draceena*, *Nyctanthes*, *Mirabilis*, *Salvadora*, Periderm formation

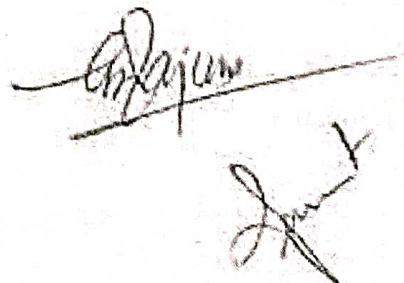
##### Suggested Readings:

1. Bhejwani, S. S. and Bhatnagar, S. P. 2000. The embryology of Angiosperms. Vikas Publ. House, New Delhi.
2. Aghwan, V. 1997. Molecular embryology of flowering plants. Cambridge Univ. Press, Camp.
3. Shivanna, K. R. and Sawhney, V. K. 1997. Pollen biotechnology for crop production and improvement Cambridge Univ. Press.
4. Shivanna, K. R. and Sawhney, V. K. Pollen Biology.
5. Forkot De. 1994. Plant growth and Development, A molecular approach, Academic Press, San Diego.
6. Howell, S. H. 1998. Molecular genetics of plant Development. Cambridge Univ. Press.
7. Leins, P., Tucker, Sc & Endress, P. K. 1988. Aspects of floral development, J. Cramer, Germany.
8. Lyndon, R. F. 1990. Plant development: The cellular basis. Unrin Hyman, London.
9. Raghavan V. 1999. Developmental Biology of flowering plants. Springer velag, New York.
10. Singh, S.P. A Textbook of Plant Anatomy.
11. Tayal, M.S. 1996. Plant Anatomy. Rastogi Publ. Meerut.

##### Lab Course (BOT20P):

1. Identification and description of locally available plants belonging to families included in the syllabus from fresh specimens, herbarium or preserved materials. After identification up to family level any suitable regional Flora may be provided for generic identification if required.
2. Description of a species based on various specimens to study intra specific variation.
3. Studies to find out the location of key characters and preparation of keys at generic level.
4. Field trips, compilation of field notes, the preparation of herbarium sheets and submission of herbarium and museum specimens and/or live potted specimens of taxonomic interest and submission of the excursion report.
5. Study of alternate and distichous, alternate and superposed, opposite and superposed opposite and decussate leaf arrangement. Examination of rosette plants (*Linnnaea*, *Mollugo*, *Raphanus*, *Hyoscyamus*, etc.) and induction of bolting under natural conditions as well as GA treatment.
6. Microscopical examination of vertical section of leaves, such as that of *Cannabis*, *Nicotiana*, *Zea mays* and *Triticum* to understand the internal structure of the tissue and trichomes, glands, etc. Also to study the anatomy of C<sub>3</sub> and C<sub>4</sub> plants.
7. Study of epidermal peels of leaves to study the development and final structure of stomata and





prepare stomatal index.

8. Study of microsporogenesis and gametogenesis in sections of anthers.
9. Examination of modes of anther dehiscence and collection of pollen grains for microscopic examination (maize, grasses, *Cannabis sativa*, *Crotolaria*, *Tradescantia*, *Brassica*, *Petunia*, *Solanum melongena*, and locally available flowers).
10. Tests for pollen viability using stains and *in vitro* germination. Pollen germination using hanging drop and sitting drop cultures.
11. Pollen storage, pollen-pistil interaction, self-incompatibility, *in vitro* pollination.
12. Food crops: wheat, rice, maize, chickpea, potato, tapioca, sweet potato, sugarcane; morphology, anatomy and micro chemical tests for stored food materials.
13. Forage fodder plants: Study of ten important fodder crops of the locality.
14. Plant fibers: Textiles fibers (cotton, jute, sun hemp, cannabis, *Grewia*, etc.), Cordage fibers (coir), Stuffing fibers (silk cotton). Morphology, anatomy, microscopic study of whole fibers using appropriate, staining procedures.
15. Medicinal and aromatic plants including narcotics and antibiotics.
16. Vegetable oils: Mustard, groundnut, soybean, coconut, sunflower and castor. Morphology, microscopic structure of oil yielding tissues, test for oil and iodine number.
17. To prepare a water extract of vegetable tannins (*Acacia*, *Terminalia*, *Camellia*, *Cassia*) and dyes (*Curcuma longa*, *Bixa orellana*, *Indigofera*, *Butea monosperma*, *Lawsonia inermis*, etc.).
18. Study of mitotic chromosomes in root tips and leaf buds and meiotic chromosomes in floral buds.
19. Isolation of chloroplasts and SDS-PAGE profile of proteins to demarcate the two subunits of Rubisco.
20. Restriction digestion of plant DNA, its separation by agarose gel electrophoresis and visualization by ethidium bromide staining.
21. Isolation of RNA and quantitation by spectrophotometric method.
22. Southern blot analysis using a gene specific probe.
23. Northern blot analysis using a gene specific probe.
24. Western blotting and ELISA.
25. Genetical problems on Mendelian and post-Mendelian ratios, gene interactions, sex-linked inheritance, chromosomal mapping, etc.

### SEMESTER III

#### Paper I (BOT301): Plant Physiology and Biochemistry

##### Unit 1

1. Functional aspects of plant cell structure: colloidal systems, concept of water potential, diffusion, osmosis and imbibition. Life giving unique properties of water.
2. Energy flow: Principles of thermodynamics, free energy and chemical potential, redox reactions; structure and functions of ATP.

##### Unit 2

1. Biologically important molecules: Carbohydrates, Amino acids, Proteins and Lipids. Fundamentals of enzymology: General aspects of enzymes, allosteric mechanism, regulatory and active sites, isozymes, kinetic catalysis, Michaelis-Menton equation and its significance.

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## SEMESTER IV

### Paper I (BOT401): Plant Breeding and Biostatistics

#### PLANT BREEDING

##### Unit 1

1. The role of plant breeding – historical aspects and genetic basis; mode of reproduction in relation to breeding methods, breeding techniques; method of plant breeding in relation to self-pollinated and cross pollinated plants.
2. Hybridization: Interspecific and inter generic; pure line; back cross hybridization, self incompatibility system.
3. Heterosis. Its genetic and physiological basis.

##### Unit 2

1. Breeding for resistance to diseases, physiological races.
2. Role of mutation in crop improving and evolution.
3. Plant breeding work done in India with special reference to potato, paddy, wheat and sugarcane.
4. Maintenance of collection, registration of varieties, seed production, testing, certification and distribution.

#### BIOSTATISTICS

##### Unit 3

1. Biostatistics and its application in life sciences.
2. Methods of representation of statistical data and measurements of central tendencies.

##### Unit 4

1. Correlation, regression, curve fitting and ratio of variation.
2. Probability and use of binomial trials.
3. Test of significance,  $\chi^2$ , 't' and 'F' tests.

#### SUGGESTED READINGS:

##### Plant Breeding:

1. Harihar, Ram, 1997. Vegetable Breeding: Principles and Practices. Jagminder Book Agency New Delhi
2. Hill, J. 1997. Quantitative and Ecological Aspects of Plant Breeding. Jagminder Book Agency. New Delhi.
3. Kapoor, R.L. 1997. Plant Breeding and Crop Improvement, 2 Vols
4. Me Donald, M.B. 1997. Seed Production: Principles and Practices.
5. Pochlman, J.M and D. Borthakur. 1969. Asian Field Crops. Oxford and IBH Publ. New Delhi.
6. Poellman, J.M and Sleeper, D.R. 1995. Breeding Field Crops. Panama Publ. House, New Delhi.
7. Sharma, J.R. 1994. Principles and Practice of Plant Breeding, Tata McGraw Hill Publ. Co. Ltd., New Delhi.
8. Singh, B.D. 2002. Plant Breeding Principles and Methods. Kalyani Publ. New Delhi.

##### Biostatistics:

1. Bliss, C.I. 1967. Statistics in Biology, 2 Vols. Me Graw Hill, New York.
2. Downey, N.M and Heath, R.W. 1960. Basic Statistical Methods, Harper International.
3. Rayner, A.A. 1969. A first Course in Biometry for Agriculture Students. Perrenmaritzburg, University of Natal Press.
4. Singh, R.K. 1994. Biometrical Techniques in Breeding and Genetics. Bishen Singh Mahendra

Pal Singh, Dehradun.

5. Watt, T. 1993. Introductory Statistics for Biology Students. Narosa, New Delhi

6. Winer, B.J. 1962. Statistical Principles in Experimental Design. Mc Graw Hill, New York.

## **Paper II (BOT402): Conservation Biology**

### **Unit 1**

1. Conservation: The basic concept, History of conservation biology.
2. The origin and evolution of organism; genetic plasticity a factor in evolution; the invasion of unoccupied ecological niches.
3. Patterns of biodiversity: Global and regional patterns of biodiversity, Distribution, Gradients, Magnitude of biodiversity, Hotspots, keystone species, effects of species deletion and addition on maintenance of biodiversity
4. Uses of biodiversity: food, fodder, timber, fibre, medicine, etc.; biodiversity based products and industries; wild relatives of cultivated plants; scientific role of biodiversity.

### **Unit 2**

1. Threats to biodiversity: Habitat loss and fragmentation, Genetic drift, Inbreeding, Disturbance, Pollution, Climate Change, Overexploitation, Invasive Species, Disease.
2. Global environmental problems: Global warming, ozone depletion, desertification.
3. Extinction to species: Susceptibility to extinction causes of species extinction, endangered species, Red and Green Data Books.

### **Unit 3**

1. Environmental Impact Assessment (EIA) origin and development, development in India, Purpose and aims of EIA, Core values and principles, EIA process, components of EIA, Participants in EIA process, Impact identification methods.
2. Conservation of Biological diversity: Genetic principles in conservation, biodiversity assessment and inventory
3. Survey and monitoring of biological resources: sampling population for biological conservation; Collection and analysis of inventory data, criteria on choice of species for conservation, People participation, biodiversity registers and their maintenance.

### **Unit 4**

1. Conservation of energy resources; conservation and maintenance of non-renewable fossil fuel resources, Conservation of biodiversity based renewable energy resources.
2. Protected Area Network, PAN with special reference to Uttarakhand and India
3. Indian biodiversity and its conservation: International efforts for conserving biodiversity viz., CITES, CBD, IUCN, MAB, UNEP, UPOV (Union for the Protection of New Plant Varieties), WTO etc.). International treaty on Plant Genetic Resources, International Agreement for conserving marine biodiversity, Wetland conservation, Rangeland management
4. Ecosystem restoration, Strategies and plans for restoration, Passive restoration (natural recovery) and active restoration.
5. Wildlife (Protection) act 1975, Forest (Conservation) Act 1980, Environment (Protection) Act 1986, Wildlife (Protection) Amendment Act 1991, Biodiversity Act 2003, etc.

### **SUGGESTED READINGS**

1. Cain, M.L., Bowman, W.D. & Hacker, S.D. 2008. Ecology. Sinauer Associates, Inc
2. Dhar, U. 1993 (Ed.). Himalayan Biodiversity: Conservation Strategies, Gyanodaya Prakashan, Nainital



3. Groombridge, B. and Jenkins, M.D. 2000. Global Biodiversity. Earth's living resources in the 21st century, UK. World conservation Monitoring Center. Pp 246.
4. Hunter, M.L.J. 1990. Wildlife, forest and forestry: Principles of Managing forests for biological diversity. Prentice Hall, Englewood, Cliffs, New Jersey. 370 pp.
5. Hunter, Jr, M.L. & Gibbs, J.P. 2000. Fundamentals of Conservation Biology. Wiley Blackwell.
6. Pullin, A. Conservation Biology. Cambridge University Press, The Edinberg Building, Cambridge CB22RU, UK.
7. Primack, R.B. 2006. Essentials of Conservation Biology. Sinauer Associates, Inc.
8. Primack, R.B. 2008. A Primer of Conservation Biology. Sinauer Associates, Inc.
9. Singh, J.S., Singh, S.P. & Gupta, S.R. 2007. Ecology, Environment and Resource Conservation. Anamaya Publishers, New Delhi.
10. Western, D. and Pearl, M.C. 1989. Conservation for twenty-first century. Oxford University Press, Oxford UK. Pp 109-120.

### **Paper III (BOT403): In-vitro technologies and industrial applications**

#### **Unit 1**

1. Micropropagation (via organogenesis and embryogenesis) of floricultural, agricultural and pharmaceutical crops. Orchids, Chrysanthemum, Gerbera, Carnation, Anthurium, Bamboos, Spilanthes, Stevia, Psoralea, Chickpea and elite tree species of national importance.
2. Production of virus free plants through meristem culture in orchids and fruit trees.
3. Germplasm conservation in vitro.

#### **Unit 2**

1. Variations: Somaclonal and gametoclonal variations, spontaneous, genetic and epigenetic variations.
2. Culture systems: Differentiated, undifferentiated, physiological, biochemical and molecular role of minerals and growth regulators in understanding differentiation of organs under in vitro conditions.
3. Problems in Plant Tissue Culture: contamination, phenolics, recalcitrance.
4. Problems in establishment of regenerated plants in nature: hardening, association of mycorrhiza and rhizobia.

#### **Unit 3**

1. Factors responsible for in vitro and ex vitro hardening.
2. Use of bioreactors in secondary metabolite production and scale up automation of plant tissue culture.

#### **Unit 4**

1. Recent applications of tissue culture techniques and biotechnology in the introduction of economically important traits in horticultural, agricultural and medicinal plants.
2. Interactions, training and workshops in Biotech industries and placements.

#### **SUGGESTED READINGS:**

1. Herman EB (2008) Media and Techniques for Growth, Regeneration and Storage 2005-2008, Agritech Publications, New York, USA.
2. Pierik RLM (1999) In Vitro Culture of Higher Plants. Kluwer Academic Publishers.
3. Prakash J & Pierik RLM (1991) Horticulture - New Technologies and Applications (Current Plant Science and Biotechnology in Agriculture). Kluwer Academic Publishers.

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4. George EF, Hall MA and Geert-Jan De Klerk (2008) Plant Propagation by Tissue Culture (3rd Edition), Springer, Netherlands.

5. Journals: Plant Cell, Tissue and Organ Culture, Plant Cell

#### Lab Course:

1. Development of regeneration protocols employing direct and indirect organogenesis / somatic embryogenesis in economically important horticultural and/or medicinal plants
2. Control of phenolics in recalcitrant tissues under culture conditions.
3. Study of various physico-chemical factors (pH, light, hormones, etc.) on in vitro growth and development of tissues or organs, rooting of regenerants, in vitro and ex vitro hardening, potting and acclimatization in natural conditions
4. Shoot-tip meristem culture for raising virus-free plants in tomato, tobacco.
5. Agrobacterium thiazogenes mediated development of hairy root cultures
6. Isolation of bioactive compounds from medicinal plants using column chromatography and TLC.
7. Preparation of synthetic seeds for germplasm conservation using somatic embryos or other propagules.

#### ELECTIVE PAPERS

##### Paper IV (a) (BOT404/F.1): Forest Ecology

###### Unit 1

1. Forests, forestry and man: Definition, forests in geological ages, forests in prehistoric era, shifting cultivation, forests in historical time, scientific forestry, forest policy, natural forest policy, private forest policy, planned forest development, forestry education in India.
2. Essential elements of forest ecology: Extent and boundaries, physical features, geology, river system, soil, land-use pattern, role in country's economy, forests and wild land.

###### Unit 2

1. Forests and trees: Locality factors of the forests, forest influences, forest composition, stand structure, dynamics and growth, classification, forest types and their distribution, species diversity.
2. Wild Life: Species and distribution, Sanctuaries, Biosphere reserves, wild life and recreation.
3. Forest conservancy and Potential Productivity: Soil, Water relation and nutrition, soil erosion and conservation, potential productivity of forests, site quality evaluation.

###### Unit 3

1. Forest Conservation and Management:
  - i) Impact of deforestation on soil and water, Role of fire: type, extent and cause of fire, fuel load, fire and different forest types of Himalaya.
  - ii) Forest resource management and forest resource information system

###### Unit 4

1. Forest cover in India-State of Art, Ground inventory, Application of Remote Sensing and Geographic Information System (GIS) in Land cover mapping, Vegetation and forest type maps.
2. Environmental Impact Assessment: Maintenance and conservational policies such as Joint Forest Management (JFM) and Agroforestry in the region.

#### Lab Course:

1. To undertake studies on stand analysis, dominance, diversity and similarity coefficient.

2. To make studies on gradient analysis.
3. To identify different forest types of the locale.
4. Calculate the Pateron week index of any natural forest stand.
5. Study ordination and continuum of different forest stands.
6. Study interspecific Association in forest stands using Plot less technique.
7. Calculate analytical and synthetic characters of different forest stands.
8. Prepare profile diagram of forest stands using Single Plot Method.

#### SUGGESTED READINGS:

1. Bir, S.S. and Chatha, G.S. 1988. Forest Vegetation Characteristics of Indian Hills. Today and Tomorrow's Printers & Publ., New Delhi.
2. Dwivedi, A.P. Forestry in India. Jugal Kishor and Company, Dehradun.
3. Misra, R. Ecology Work Book. Oxford & IBH Publishing Co. New Delhi.
4. Mishra, R. and Gopal, B. Recent Advances in Tropical Ecology: Part I & II. International Society for Tropical ecology, Varanasi.
5. Negi, S.S. 1983. Forest Ecology. Bishen Singh Mahendra Pal Singh, Dehradun.
6. Puri, G.S., Gupta, R.K., Meher-Homji, V.M. and Puri, S. 1989. Forest Ecology- Plant Form, Diversity, Communities and Succession. Oxford and IBH Publishing Co. Pvt. Ltd. New Delhi.
7. Puri, G.S., Meher-Homji, V.M., Gupta, R.K. and Puri, S. Forest Ecology, Vol I & II. Oxford and IBH Publishing Co. Pvt. Ltd. New Delhi.
8. Singh, G. 1987. Forest Ecology of India. Rawat Publications, Jaipur.
9. Singh, J.S. and Singh, S.P. 1992. Forests of Himalaya. Consul Book Depot. Gyanodaya Prakashan, Nainital, India.
10. Singh, J.S. Singh, S.P. and Gupta, S.R. 2005. Ecology, Environment and Resource Conservation. Anamaya Publ., F-154/2 Ladosrai, New Delhi- 110 050.
11. Singh, M.P. and Vishwakarma, V. 1997. Forest Environment and Biodiversity. Daya Publ. House, Delhi.
12. Waring, R.H. and Schlesinger, W.H. 1985. Forest Ecosystems: Concepts and Management. Academic Press. New York.

#### Paper IV (b) (BOT404/E2): Industrial Microbiology

##### Unit 1

1. Introduction to industrial microbiology-Range of fermentation processes, microbial biomass, microbial enzymes, microbial metabolites and transformation processes.
2. Selection and strain improvement strategies - Isolation of industrially important microorganisms - primary and secondary screening. Detection and assay of fermentation products - physical-chemical, biological assays. Preservation of microbes -storage at reduced temperature, storage in dehydrated forms.

##### Unit 2

1. Types of fermentation - Solid state fermentation and submerged fermentation; batch, continuous and fed batch fermentation. Homo- and heterofermentation. Aerobic and anaerobic fermentation. Static and stirred fermentations. Media for microbial growth and fermentation - Typical media, media formulation; water, energy and carbon source, nitrogen sources, minerals and vitamins, buffers, precursors, metabolic regulators, oxygen requirement.
2. Bioreactors - Brief study on stirred tank fermenter, air-lift fermenter, packed tower fermenter, tray fermenter, rotary drum fermenter. Microbial fermentation- Sterilization -

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media, fermenter, air. Inoculum preparation, inoculation, Aeration, agitation, pH control, temperature control, antifoam agents Process parameter optimization: One factor at a time and statistical optimizations (brief study only) Scale up of fermentation (lab scale, pilot plant, industrial scale).

### Unit 3

1. Downstream processing- Separation of microbial cells - Filtration, precipitation, centrifugation.
2. Cell disruption - liquid shear, freezing-thawing, ultrasonication, osmotic shock, enzyme treatment. Concentrating and purifying the products - ultrafiltration, crystallization, solvent precipitation, reverse osmosis, chromatography Production of industrially important products

### Unit 4

1. Antibiotics - Penicillin, Streptomycin, Amino acids - Lysine, Glutamic acid Enzymes - Amylase, Cellulase, Pectinase. Organic acids - Lactic acid, Acetic acid, Gluconic acid, Biofuels - Bio-ethanol, Bio-butanol, Biopolymers - PHB, PLA, Alcoholic beverages - Wine, Beer, Microbial cells - SCP.
2. Baker's yeast, Immobilization of cells and enzymes- Methods of cell and enzyme immobilization. Applications of immobilized cells and enzymes.

### Lab Course

1. Screening and isolation of microbes for production of organic acids and enzymes.
2. Preparation and maintenance of stock cultures (Bacteria and Fungi).
3. Preparation of bacterial inoculum by measuring OD and enumeration of bacterial cells by serial dilution and pour plate (or spread plate) method.
4. Solid state and Submerged fermentation for amylase (or any other enzyme) production and quantification of product by suitable assay methods.
5. Optimization of process parameters for enzyme production in submerged fermentation.
6. Partial purification of amylase (or any other enzyme) produced by microbial fermentation using acetone precipitation.
7. Immobilization of yeast cells and sugar fermentation using immobilized cells.

### Suggested readings:

1. Madigan, M. E., J.M. Martink and J. Parker (1997). Brock Biology of Microorganism. Prentice hall International, Inc., New Jersey.
2. Prescott (2000) Microbiology
3. Cruizer, W. and A. Cruizer (1990). A Textbook of Industrial Microbiology.
4. Alexander, M. (1977). Soil Microbiology. John Wiley and Sons, New York.
5. Dubey, R.C. and D.K. Maheshwan (2010). A Textbook of Microbiology. S. Chand and Co. Pvt. Ltd. New Delhi.

### Paper IV (c) (BOT404/E3): Ethnobotany

#### Unit I

1. Introduction, concept, scope and objectives. Linkage of Ethnobotany with other sciences and disciplines in biology - food and nutrition, medicine, sociological and cultural practices, religions and social costumes and economic relations.
2. Ethnic groups and Ethnobotany: Major and minor ethnic groups of Uttarakhand and their life styles. Forest v/s Ethnic groups.

## Unit 2

1. Methodology of Ethnobotanical studies: Field work, Herbarium, Ancient literature, Archaeological findings, Temples and sacred places, Protocols, Plants and Tribal medicine: Significance of *Crotalaria orchoides*, *Cassia speciosa*, *Urtica superba*, *Sida monosperma*, *Wrightia tinctoria* and *Pongamia pinnata* in Ethno-medical practices along with a brief note on their habitat and morphology.
2. Medico-ethnobotanical research in Uttarakhand

## Unit 3

1. Different systems of indigenous medicine (Traditional medicine, Ayurveda, Siddha, Unani), Homeopathy and Allopathy; Role of Phytomedicine in modern systems of medicine.
2. Classification of drugs; analytical methods - drug adulteration, drug evaluation, anatomical and phytochemical analysis of crude drugs; preliminary screening, fractionation and separation of different groups of biodynamic compounds and biological evaluation.

## Unit 4

1. Phytopharmaceuticals, Drugs of alkaloids, coumarins, volatile oils, tannins, resins and gums. Natural pesticides, antibiotics, allergens and poisonous plants. Economic potential of phytomedicine; potential drug yielding plants and their marketing avenues. IPR and patenting of active principles.
2. Ethnobotany and conservation of plants with special reference to Uttarakhand - mythology and conservation of ecosystems, conservation of selected plant species: sacred groves, forestry and unique ecosystems and their ethnobiological values, plants and animals in art, tradition and ethnography; methodologies in ethno-botanical research

## Lab Course:

1. Preparation of the herbarium specimen medicinally important plants.
2. Listing of plants used by villagers and on the basis of their local use to place them in the field of the study of ethnobotanical research.
3. Study of Economic potential of Phytomedicine and role of phytomedicine in modern system of medicine.

## Suggested Readings:

1. S.K. Jain, Manual of ethnobotany, scientific publishers, Jodhpur, 1995.
2. S.K. Jain (ed.) Glimpses of Indian Ethnobotany, Oxford and I B H, New Delhi, 1981.
3. S.K. Jain, (ed.) Methods and approaches in ethnobotany, Society of Ethnobotanists, Lucknow, India, 1989.
4. S.K. Jain, Contributions of Indian ethnobotany, Scientific Publishers, Jodhpur, 1990.
5. Colton C.M. Ethnobotany-Principles and applications, John Wiley and sons-Chichester, 1997.
6. Rama R. N. and A.N. Henry, The ethnobotany of Eastern Ghats in Andhra Pradesh, India Botanical Survey of India, Howrah, 1996.
7. Rajiv K. Sinha, Ethnobotany-the renaissance of traditional Herbal Medicine-I N A- Shree publishers, Jaipur, 1996.

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**Paper IV (d) (BOT404/E4): PALYNOLOGY AND POLLINATION BIOLOGY**

**Unit 1**

1. General Introduction, microsporogenesis, microspore tetrads and polarity of spores and pollen grains
2. Pollen wall development and pollen chemistry. Chemical nature of sporopollenin, development of pollen wall, Ubisch body, pollen wall proteins, origin and formation of exineless pollen grains, pollen expressed and pollen specific genes

**Unit 2**

1. Spore-pollen morphology: Symmetry, shape, size, aperture patterns, NPC System for numerical expression of apertural details, exine stratification, surface structures and sculptures of sporoderm; LO-analysis and edge-analysis.
2. Palynotaxonomy, Systematic palynology, identification key and evolutionary trends among pollen grains based on palynotaxonomical works.
3. Acropalynology with reference to allergy: Aeroallergens, introductory idea of Immune System with special reference to IgE. Study of airspora, identification of allergic taxa by *in vivo* and *in vitro* tests with spore-pollen extracts, chemical nature of exine-borne allergens, allergic taxa of North-West Himalaya.

**Unit 3**

1. **Melissopalynology:** Indian species of honey bees, importance of pollen grains as constituent of bee-bread, pollen-collecting mechanism of honey bees, analysis of pollen load and honey sample in understanding bee forage, objectives of melissopalynological studies, important bee plants of North- West Himalaya.
2. **Palaeopalynology:** Introductory idea about palaeopalynological remains, significance of palaeopalynology.

**Unit 4**

1. Forensic palynology: Definition and significance, a few well-known case studies.
2. Pollination Biology: Pollen dispersal units; pollination types, contrivances for cross- and self-pollination; pollen vectors, pollination modes and flora organization, Pollen viability and storage, evolutionary trends in pollination modes. Breeding systems, incompatibility and compatibility control with reference to pollen-pistil interactions and pollen biotechnology.

**Lab Course**

1. Pollen morphological studies of some pteridophytes, gymnosperms, and angiosperms representing different morphological types using acetolysis / alkali maceration method.
2. Extraction of pollen grains from honey sample and study of the frequency of different morpho-types.
3. Study of *in vivo* and *in vitro* germination of pollen grains.
4. Morpho-anatomical study of stigma and style.
5. Study of the growth of pollen tube through stigma and style.
6. Study of allergy producing pollen morpho-types.

**SUGGESTED READINGS:**

1. Crane, Eva; Walker, Penelope and Day Rosemary, 1984. Directory of Important World Honey Sources: International Bee Research Association, London.
2. Erdman, G. 1952. Pollen Morphology and Plant Taxonomy, Angiosperms, Almqvist and Wiksell, Stockholm.

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3. Knut Segril, Johnson Iverson. 1975. Text book of pollen analysis 4rd edition Blackwell Publ.
4. Nair, P.K.K. 1966. Essentials of Palynology. Asia Publication House Lucknow.
5. Woodhouse, R.P. 1935. Pollen Grains. Hafner Publication Co.

#### Paper IV (c) (BOT404/E5): Seed Pathology

##### Unit 1

1. Introduction, terminology and historical development, seed health and its importance.
2. Kinds of seed borne pathogens: fungi, bacteria, viruses, viroids and nematodes.
3. Types of damage caused by the seed borne fungi to seeds and crops.

##### Unit 2

1. Nature of seed infection. Systemic infection through flower, fruit and seed stock. Penetration through seed coat, natural openings and inflicted openings.
2. Longevity of seed borne pathogens. Factors influencing longevity.

##### Unit 3

1. Epiphytology of seed borne diseases, monocyclic and polycyclic diseases.
2. Detection of seed borne pathogens, objectives of seed health testing. Testing methods for seed borne fungi, seed borne bacteria, seed borne viruses and seed borne nematodes.

##### Unit 4

1. Study of seed borne diseases of certain specific crops, cereals, millets, pulses, oil crops, fibre crops, and vegetable and timber crops.
2. Control of seed borne pathogens: selection of seed production areas, crop management, seed treatment, certification, plant quarantine and disease resistance.

##### Lab Course

1. Isolation and inoculation of mycorrhiza.
2. Study of seed borne pathogen. Description of pathogen, symptoms and section cutting.
3. Isolation of some important pathogens.
4. Procedure of equipments uses.
5. To establish a plant disease clinic in the department for advise to local people.

##### SUGGESTED READINGS

1. Neergard P. 1977. Seed Pathology Vol I and II. MacMillan Press, London.
2. Suryanarayan, D. 1978. Seed Pathology. Vikas Publ. House. Pvt. Ltd. New Delhi.
3. Jha, D.K. 1995. A Text Book of Seed Pathology. Vikas Publ. House. Pvt. Ltd. New Delhi.
4. Agarwal, V.K. 1978. Principles of Seed Pathology. In (ed.) James B.S. Sindair. CRC Press. II Edition.
5. Desai, B.B. Seed Handbook. CRC Press.
6. Singh, Gurnam. Seed Pathology. Pointer Publisher, Jaipur.
7. Singh, T. Seed Technology and Seed Pathology. Pointer Publisher, Jaipur.
8. Nene, Y.L. and Agarwal, V.K. 1978. Some seed borne diseases and their control. ICAR, New Delhi.

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**Lab Course : BOT40P\***

1. Emasculation, bagging and hand pollination techniques to study pollen germination.  
Application of common plant breeding techniques
2. Floral biology of local food, pulse, vegetable and horticultural crop
3. To test the goodness of fit and independent assortment using Chi-square method
4. To study the pattern of regional biodiversity
5. To study the Hot spots and key stone species.
6. Survey of biological resources.
7. Study of habitat loss with respect to plant species. To observe factors expediting habitat loss viz., floods, forest fires, landslides, natural and anthropological activities.
8. Visits to national parks, sanctuaries and biosphere reserves of Uttarakhand.
9. Visit to ecosystem restoration sites in mined areas in Uttarakhand Himalayas.
10. PTC - Laboratory organization, different sterilization aseptic technique.
11. Preparation and sterilization of media
12. Callus culture (morphological and internal structure) and suspension cultures (growth curve)
13. Shoot tip, axillary bud, nodal explant culture
14. Root tip and leaf culture.
15. Protoplast isolation and fusion
16. Somatic embryogenesis and production of artificial seeds.
17. Anther, pollen, ovule culture.

\*Additional lab course of selected elective paper.

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## SEMESTER IV

### Paper I (BOT401): Plant Breeding and Biostatistics

#### PLANT BREEDING

##### Unit 1

1. The role of plant breeding - historical aspects and genetic basis; mode of reproduction in relation to breeding methods, breeding techniques; method of plant breeding in relation to self-pollinated and cross pollinated plants.
2. Hybridization. Interspecific and inter generic; pure line; back cross hybridization, self-incompatibility system.
3. Heterosis. Its genetic and physiological basis.

##### Unit 2

1. Breeding for resistance to diseases, physiological races.
2. Role of mutation in crop improving and evolution.
3. Plant breeding work done in India with special reference to potato, paddy, wheat and sugarcane.
4. Maintenance of collection, registration of varieties, seed production, testing, certification and distribution.

#### BIOSTATISTICS

##### Unit 3

1. Biostatistics and its application in life sciences.
2. Methods of representation of statistical data and measurements of central tendencies.

##### Unit 4

1. Correlation, regression, curve fitting and ratio of variation.
2. Probability and use of binomial trials.
3. Test of significance,  $\chi^2$ , 't' and 'F' tests.

#### SUGGESTED READINGS:

##### Plant Breeding:

1. Harihar, Rama, 1997. Vegetable Breeding, Principles and Practices. Jagminder Book Agency, New Delhi.
2. Hill, J. 1997. Quantitative and Ecological Aspects of Plant Breeding, Jagminder Book Agency, New Delhi.
3. Kapoor, R.L. 1997. Plant Breeding and Crop Improvement, 2 Vols.
4. McDonald, M.B. 1997. Seed Production: Principles and Practices.
5. Poehlman, J.M and D. Borthakur, 1969. Asian Field Crops. Oxford and IBH Publ. New Delhi.
6. Poehlman, J.M and Sleeper, D.R. 1995. Breeding Field Crops. Panama Publ. House, New Delhi.
7. Sharma, J.R. 1994. Principles and Practice of Plant Breeding. Tata McGraw Hill Publ. Co. Ltd., New Delhi.
8. Singh, B.D. 2002. Plant Breeding Principles and Methods. Kalyani Publ. New Delhi.

##### Biostatistics:

1. Bliss, C.I. 1967. Statistics in Biology, 2 Vols. Mc Graw Hill, New York.
2. Downey, N.M and Heath, R.W. 1960. Basic Statistical Methods, Harper International.
3. Rayner, A.A. 1969. A first Course in Biometry for Agriculture Students. Peitermanitzberg, University of Natal Press.
4. Singh, R.K. 1994. Biometrical Techniques in Breeding and Genetics. Bishen Singh Mahendra

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4. Watt, T. 1993. Introductory Statistics for Biology Students. Narosa, New Delhi

6. Winet, B.I. 1962. Statistical Principles in Experimental Design. Mc Graw Hill, New York.

## Paper II (BOT402): Conservation Biology

### Unit 1

1. Conservation: The basic concept, History of conservation biology.
2. The origin and evolution of organism; genetic plasticity a factor in evolution; the invasion of unoccupied ecological niches.
3. Patterns of biodiversity: Global and regional patterns of biodiversity, Distribution, Gradients, Magnitude of biodiversity, Hotspots, keystone species, effects of species deletion and addition on maintenance of biodiversity.
4. Uses of biodiversity: food, fodder, timber, fibre, medicine, etc.; biodiversity based products and industries; wild relatives of cultivated plants; scientific role of biodiversity.

### Unit 2

1. Threats to biodiversity: Habitat loss and fragmentation, Genetic drift, Inbreeding, Disturbance, Pollution, Climate Change, Overexploitation, Invasive Species, Disease.
2. Global environmental problems: Global warming, ozone depletion, desertification
3. Extinction to species: Susceptibility to extinction causes of species extinction, endangered species, Red and Green Data Books

### Unit 3

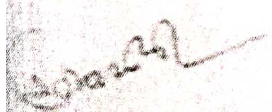
1. Environmental Impact Assessment (EIA) origin and development, development in India. Purpose and aims of EIA, Core values and principles, EIA process, components of EIA, Participants in EIA process, Impact identification methods.
2. Conservation of Biological diversity: Genetic principles in conservation; biodiversity assessment and inventory
3. Survey and monitoring of biological resources: sampling population for biological conservation; Collection and analysis of inventory data, criteria on choice of species for conservation, People participation, biodiversity registers and their maintenance.

### Unit 4

1. Conservation of energy resources; conservation and maintenance of non-renewable fossil fuel resources; Conservation of biodiversity based renewable energy resources.
2. Protected Area Network, PAN with special reference to Uttarakhand and India
3. Indian biodiversity and its conservation: International efforts for conserving biodiversity viz., CITES, CBD, IUCN, MAB, UNEP, UPOV (Union for the Protection of New Plant Varieties), WTO etc.; International treaty on Plant Genetic Resources, International Agreement for conserving marine biodiversity, Wetland conservation, Rangeland management
4. Ecosystem restoration, Strategies and plans for restoration, Passive restoration (natural recovery) and active restoration.
5. Wildlife (Protection) Act 1975, Forest (Conservation) Act 1980, Environment (Protection) Act 1986, Wildlife (Protection) Amendment Act 1991, Biodiversity Act 2003, etc.

### SUGGESTED READINGS

1. Cain, M.L., Bowman, W.D. & Hacker, S.D. 2008. Ecology. Sinauer Associates, Inc
2. Dhar, U. 1993 (Ed.). Himalayan Biodiversity. Conservation Strategies. Oyanodaya Prakashan, Nainital



3. Groombridge, H. and Jenkins, M.D. 2000. Global Biodiversity, Earth's living resources in the 21st century, UK. World conservation Monitoring Center. Pp 246
4. Hunter, M.L.J. 1990. Wildlife, forest and forestry: Principles of Managing forests for biological diversity. Prentice Hall, Englewood, Cliffs, New Jersey. 370 pp.
5. Hunter, Jr, M.L. & Gibbs, J.P. 2006. Fundamentals of Conservation Biology. Wiley Blackwell.
6. Pullin, A Conservation Biology. Cambridge University Press, The Edinburgh Building, Cambridge CB2 2RU, UK.
7. Primack, R.B. 2006. Essentials of Conservation Biology. Sinauer Associates, Inc.
8. Primack, R.B. 2008. A Primer of Conservation Biology. Sinauer Associates, Inc.
9. Singh, J.S., Singh, S.P. & Gupta, S.R. 2007. Ecology, Environment and Resource Conservation. Anamaya Publishers, New Delhi
10. Western, D. and Pearl, M.C. 1989. Conservation for twenty-first century. Oxford University Press, Oxford UK. Pp 109-120.

### Paper III (BOT403): In-vitro technologies and industrial applications

#### Unit 1

1. Micropropagation (via organogenesis and embryogenesis) of floricultural, agricultural and pharmaceutical crops: Orchids, Chrysanthemum, Gerbera, Carnation, Anabarium, Bamboos, Spilanthes, Stevia, Psoralea, Chickpea and elite tree species of national importance.
2. Production of virus free plants through meristem culture in orchids and fruit trees.
3. Germplasm conservation in vitro.

#### Unit 2

1. Variations: Somaclonal and gametoclonal variations, spontaneous, genetic and epigenetic variations.
2. Culture systems: Differentiated, undifferentiated, physiological, biochemical and molecular role of minerals and growth regulators in understanding differentiation of organs under in vitro conditions.
3. Problems in Plant Tissue Culture: contamination, phenolics, recalcitrance.
4. Problems in establishment of regenerated plants in nature: hardening, association of mycorrhiza and rhizobia.

#### Unit 3

1. Factors responsible for in vitro and ex vitro hardening.
2. Use of bioreactors in secondary metabolite production and scale up automation of plant tissue culture.

#### Unit 4

1. Recent applications of tissue culture techniques and biotechnology in the introduction of economically important traits in horticultural, agricultural and medicinal plants.
2. Interactions, training and workshops in Biotech industries and placements.

#### SUGGESTED READINGS:

1. Herman EB (2008) Media and Techniques for Growth, Regeneration and Storage 2005-2008, Agritech Publications, New York, USA.
2. Pierik RLM (1999) In Vitro Culture of Higher Plants. Kluwer Academic Publishers.
3. Prakash J & Pierik RLM (1991) Horticulture - New Technologies and Applications (Current Plant Science and Biotechnology in Agriculture). Kluwer Academic Publishers.

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4. George EF, Hall MA and Geert-Jan De Klerk (2008). Plant Propagation by Tissue Culture (3rd Edition), Springer, Netherlands

5. Journals: Plant Cell, Tissue and Organ Culture, Plant Cell

#### Lab Course:

1. Development of regeneration protocols employing direct and indirect organogenesis / somatic embryogenesis in economically important horticultural and/or medicinal plants
2. Control of phenolics in recalcitrant tissues under culture conditions.
3. Study of various physico-chemical factors (pH, light, hormones, etc.) on *in vitro* growth and development of tissues or organs, rooting of regenerants, *in vitro* and *ex vitro* hardening, praling and acclimatization in natural conditions
4. Shoot-tip meristem culture for raising virus-free plants in tomato / tobacco.
5. Agrobacterium rhizogenes mediated development of hairy root cultures
6. Isolation of bioactive compounds from medicinal plants using column chromatography and TLC.
- \* Preparation of synthetic seeds for germplasm conservation using somatic embryos or other propagules.

#### ELECTIVE PAPERS

##### Paper IV (a) (BOT404/E.1): Forest Ecology

###### Unit 1

1. Forests, forestry and man: Definition, forests in geological ages, forests in pre-historic era, shifting cultivation, forests in historical time, scientific forestry, forest policy, natural forest policy, private forest policy, planned forest development, forestry education in India.
2. Essential elements of forest ecology: Extent and boundaries, physical features, geology, river system, soil, land-use pattern, role in country's economy, forests and wild land.

###### Unit 2

1. Forests and trees: Locality factors of the forests, forest influences, forest composition, stand structure, dynamics and growth, classification, forest types and their distribution, species diversity
2. Wild Life: Species and distribution, Sanctuaries, Biosphere reserves, wild life and recreation.
3. Forest conservancy and Potential Productivity: Soil, Water relation and nutrition, soil erosion and conservation, potential productivity of forests, site quality evaluation

###### Unit 3

1. Forest Conservation and Management:
  - a) Impact of deforestation on soil and water, Role of fire: type, extent and cause of fire, fuel load, fire and different forest types of Himalaya.
  - b) Forest resource management and forest resource information system

###### Unit 4

1. Forest cover in India-State of Art, Ground inventory, Application of Remote Sensing and Geographic Information System (GIS) in Land cover mapping, Vegetation and forest type maps.
2. Environmental Impact Assessment: Maintenance and conservational policies such as Joint Forest Management (JFM) and Agroforestry in the region.

#### Lab Course:

1. To undertake studies on stand analysis, dominance, diversity and similarity coefficient.

1. To make studies on gradient analysis
2. To identify different forest types of the locale
3. Calculate the Pateron week index of any natural forest stand.
4. Study ordination and continuum of different forest stands.
5. Study interspecific Association in forest stands using Plot less technique.
6. Calculate analytical and synthetic characters of different forest stands.
7. Prepare profile diagram of forest stands using Single Plot Method.

#### SUGGESTED READINGS:

1. Bir, S.S. and Chatha, G.S. 1985. Forest Vegetation Characteristics of Indian Hills. Today and Tomorrow's Printers & Publ., New Delhi.
2. Dhivedi, A.P. Forestry in India. Jugal Kishor and Company, Dehradun.
3. Misra, R. Ecology Work Book. Oxford & IBH Publishing Co. New Delhi
4. Mishra, R. and Goyal, B. Recent Advances in Tropical Ecology: Part I & II. International Society for Tropical ecology, Varanasi
5. Negi, S.S. 1983. Forest Ecology. Bishen Singh Mahendra Pal Singh, Dehradun.
6. Pari, G.S., Gupta, R.K., Meher-Homji, V.M. and Pari, S. 1989. Forest Ecology: Plant Form, Diversity, Communities and Succession. Oxford and IBH Publishing Co. Pvt. Ltd. New Delhi.
7. Pari, G.S., Meher-Homji, V.M., Gupta, R.K. and Pari, S. Forest Ecology, Vol I & II. Oxford and IBH Publishing Co. Pvt. Ltd. New Delhi.
8. Singh, G. 1987. Forest Ecology of India. Rawat Publications, Jaipur
9. Singh, J.S. and Singh, S.P. 1992. Forests of Himalaya. Consul Book Depot. Gyanodaya Prakashan, Nainital, India.
10. Singh, J.S. Singh, S.P. and Gupta, S.R. 2005. Ecology, Environment and Resource Conservation. Anamaya Publ., F-154/2 Ladosarai, New Delhi- 110 050
11. Singh, M.P. and Vishwakarma, V. 1997. Forest Environment and Biodiversity. Daya Publ. House, Delhi.
12. Wareing, R.H. and Schlesinger, W.H. 1985. Forest Ecosystems: Concepts and Management. Academic Press, New York.

#### Paper IV (b) (BOT404/E2): Industrial Microbiology

##### Unit 1

1. Introduction to industrial microbiology - Range of fermentation processes, microbial biomass, microbial enzymes, microbial metabolites and transformation processes.
2. Selection and strain improvement strategies - Isolation of industrially important microorganisms - primary and secondary screening. Detection and assay of fermentation products - physical-chemical, biological assays. Preservation of microbes - storage at reduced temperature, storage in dehydrated forms.

##### Unit 2

1. Types of fermentation - Solid state fermentation and submerged fermentation; batch, continuous and fed batch fermentation. Homo- and heterofermentation. Aerobic and anaerobic fermentation. Static and stirred fermentations. Media for microbial growth and fermentation - Typical media, media formulation; water, energy and carbon source, nitrogen sources, minerals and vitamins, buffers, precursors, metabolic regulators, oxygen requirement.
2. Bioreactors - Brief study on stirred tank fermenter, air lift fermenter, packed tower fermenter, tray fermenter, rotary drum fermenter. Microbial fermentation - Sterilization -

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media, fermenter, air. Inoculum preparation, inoculation. Aeration, agitation, pH control, temperature control, antifungal agents. Process parameter optimization - One factor at a time and statistical optimizations (brief study only.) Scale up of fermentation (lab scale, pilot plant, industrial scales).

#### Unit 3

1. Downstream processing- Separation of microbial cells - Filtration, precipitation, centrifugation.
2. Cell disruption - liquid shear, freezing-thawing, ultrasonication, osmotic shock, enzyme treatment. Concentrating and purifying the products - ultrafiltration, crystallization, solvent precipitation, reverse osmosis, chromatography. Production of industrially important products

#### Unit 4

1. Antibiotics - Penicillin, Streptomycin, Amino acids - Lysine, Glutamic acid. Enzymes - Amylase, Cellulase, Pectinase, Organic acids - Lactic acid, Acetic acid, Gluconic acid, Biofuels - Bio-ethanol, Bio-butanol, Biopolymers - PHB, PLA, Alcoholic beverages - Wine, Beer, Microbial cells - SCP.
2. Baker's yeast, Immobilization of cells and enzymes- Methods of cell and enzyme immobilization, Applications of immobilized cells and enzymes.

#### Lab Course

1. Screening and isolation of microbes for production of organic acids and enzymes.
2. Preparation and maintenance of stock cultures (Bacteria and Fungi).
3. Preparation of bacterial inoculum by measuring OD and enumeration of bacterial cells by serial dilution and pour plate (or spread plate) method.
4. Solid state and Submerged fermentation for amylase (or any other enzyme) production and quantification of product by suitable assay methods.
5. Optimization of process parameters for enzyme production in submerged fermentation.
6. Partial purification of amylase (or any other enzyme) produced by microbial fermentation using acetone precipitation.
7. Immobilization of yeast cells and sugar fermentation using immobilized cells.

#### Suggested readings:

1. Madigan, M. T., J.M. Martink and J. Parker (1997). Brock Biology of Microorganism, Prentice hall International, Inc., New, Jersey.
2. Prescott (2000). Microbiology.
3. Cruzeir, W. and A. Cruzeir (1990). A Textbook of Industrial Microbiology.
4. Alexander, M. (1977). Soil Microbiology. John Wiley and Sons, New York.
5. Dubey, R.C. and D.K. Maheshwari (2010). A Textbook of Microbiology. S. Chand and Co. Pvt. Ltd. New Delhi.

#### Paper IV (c) (BOT404/E3): Ethnobotany

##### Unit I

1. Introduction, concept, scope and objectives. Linkage of Ethnobotany with other sciences and disciplines in biology - food and nutrition, medicine, sociological and cultural practices, religions and social customs and economic relations.
2. Ethnic groups and Ethnobotany: Major and minor ethnic groups of Uttarakhand and their life styles. Forest v/s Ethnic groups.

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## Unit 2

1. Methodology of Ethnobotanical studies: Field work, Herbarium, Ancient Literature, Archaeological findings, Temples and sacred places, Protocols, Plants and Tribal medicine: Significance of *Uncaria gambir*, *Cordia alliodora*, *Cordia speciosa*, *Glossa superba*, *Sida mono-perma*, *Hrightia pictoria* and *Forgantia pinnata* in Ethno-medical practices along with a brief note on their habitat and morphology.
2. Medicines-ethnobotanical research in Uttarakhand

## Unit 3

1. Different systems of indigenous medicine (Traditional medicine, Ayurveda, Siddha, Unani), Homeopathy and Allopathy: Role of Phytomedicine in modern systems of medicine.
2. Classification of drugs, analytical methods - drug adulteration, drug evaluation, anatomical and phytochemical analysis of crude drugs, preliminary screening, fractionation and separation of different groups of biodynamic compounds and biological evaluation.

## Unit 4

1. Phytopharmaceuticals: Drugs of alkaloids, coumarins, volatile oils, tannins, resins and gums. Natural pesticides, antibiotics, allergens and poisonous plants. Economic potential of phytomedicine; potential drug yielding plants and their marketing avenues, IPR and patenting of active principles.
2. Ethnobotany and conservation of plants with special reference to Uttarakhand - mythology and conservation of ecosystems, conservation of selected plant species, sacred groves, forestry and unique ecosystems and their ethnobiological values, plants and animals in art, tradition and ethnography; methodologies in ethno-botanical research.

## Lab Course:

1. Preparation of the herbarium specimen medicinally important plants.
2. Listing of plants used by villagers and on the basis of their local use to place them in the field of the study of ethnobotanical research.
3. Study of Economic potential, of Phytomedicine and role of phytomedicine in modern system of medicine.

## Suggested Readings:

1. S.K. Jain, Manual of ethnobotany, scientific publishers, Jodhpur, 1995.
2. S.K. Jain (ed.) Glimpses of Indian Ethnobotany, Oxford and I.B.H. New Delhi, 1981.
3. S.K. Jain, (ed.) Methods and approaches in ethnobotany, Society of Ethnobotanists, Lucknow, India, 1980.
4. S.K. Jain, Contributions of Indian ethnobotany, Scientific Publishers, Jodhpur, 1990.
5. Colton C.M. Ethnobotany-Principles and applications, John Wiley and sons-Chichester, 1997.
6. Rama R. N. and A.N. Henry, The ethnobotany of Eastern Ghats in Andhra Pradesh, India Botanical Survey of India, Howrah, 1996.
7. Rajiv K. Sinha, Ethnobotany-the renaissance of traditional Herbal Medicine I.N.A. Shree publishers, Jaipur, 1996.

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## Paper IV (d) (BOT404 E4): PALYNOLOGY AND POLLINATION BIOLOGY

### Unit 1

1. General Introduction, microsporogenesis, microspore tetrads and polarity of spores and pollen grains.
2. Pollen wall development and pollen chemistry. Chemical nature of sporopollenin, development of pollen wall, Ubisch body, pollen wall proteins, origin and formation exemplifies pollen grains, pollen expressed and pollen specific genes.

### Unit 2

1. Spore-pollen morphology: Symmetry, shape, size, aperture patterns, NPC, System for numerical expression of apertural details, exine stratification, surface structures and sculptures of sporoderm: LO-analysis and edge-analysis.
2. Palynotaxonomy, Systematic palynology, identification key and evolutionary trends among pollen grains based on palynotaxonomical works.
3. Acropalynology with reference to allergy: Aeroallergens, introductory idea of Immune System with special reference to IgE. Study of anther, identification of allergic taxa by *in vivo* and *in vitro* tests with spore-pollen extracts, chemical nature of extra-biotic allergens, allergic taxa of North-West Himalaya.

### Unit 3

1. **Melissopalynology:** Indian species of honey bees, importance of pollen grains as constituent of bee-bread, pollen-collecting mechanism of honey bees, analysis of pollen load and honey sample in understanding bee forage, objectives of melissopalynological studies, important bee plants of North- West Himalaya.
2. **Palaeopalynology:** Introductory idea about palaeopalynological remains, significance of palaeopalynology.

### Unit 4

1. Forensic palynology: Definition and significance, a few well-known case studies.
2. Pollination Biology: Pollen dispersal units: pollination types, contrivances for cross- and self-pollination: pollen vectors, pollination modes and flora organization, Pollen viability and storage, evolutionary trends in pollination modes, Breeding systems, incompatibility and compatibility control with reference to pollen-pistil interactions and pollen biotechnology.

### Lab Course

1. Pollen morphological studies of some pterocophytes, gymnosperms, and angiosperms representing different morphological types using acetolysis - alkali maceration method.
2. Extraction of pollen grains from honey sample and study of the frequency of different morpho-types.
3. Study of *in vivo* and *in vitro* germination of pollen grains.
4. Morpho-anatomical study of stigma and style.
5. Study of the growth of pollen tube through stigma and style.
6. Study of allergy producing pollen morpho-types.

### SUGGESTED READINGS:

1. Crane, Eva; Walker, Penelope and Day Rosemary, 1984, Directory of Important World Honey Sources: International Bee Research Association, London.
2. Friiman, G. 1982, Pollen Morphology and Plant Taxonomy, Angiosperms, Almqvist and Wiksell, Stockholm.

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3. Knut Segril, Johnson Iverson. 1975. Text book of pollen analysis 3rd edition Blackwell Publ.
4. Nair, P.K.K. 1966. Essentials of Palynology. Asia Publication House Lucknow.
5. Woodhouse, R.P. 1935. Pollen Grains. Hafner Publication Co.

#### Paper IV (c) (BOT 404/E5): Seed Pathology

##### Unit 1

1. Introduction, terminology and historical development, seed health and its importance.
2. Kinds of seed borne pathogens: fungi, bacteria, viruses, viroides and nematodes.
3. Types of damage caused by the seed borne fungi to seeds and crops.

##### Unit 2

1. Nature of seed infection. Systemic infection through flower, fruit and seed stock. Penetration through seed coat, natural openings and inflicted openings.
2. Longevity of seed borne pathogens. Factors influencing longevity.

##### Unit 3

1. Epiphytology of seed borne diseases, monocyclic and polycyclic diseases.
2. Detection of seed borne pathogens, objectives of seed health testing. Testing methods for seed borne fungi, seed borne bacteria, seed borne viruses and seed borne nematodes.

##### Unit 4

1. Study of seed borne diseases of certain specific crops, cereals, millets, pulses, oil crops, fibre crops, and vegetable and timber crops.
2. Control of seed borne pathogens: selection of seed production areas, crop management, seed treatment, certification, plant quarantine and disease resistance.

##### Lab Course

1. Isolation and inoculation of mycorrhiza.
2. Study of seed borne pathogen. Description of pathogen, symptoms and section cutting.
3. Isolation of some important pathogens.
4. Procedure of equipments uses.
5. To establish a plant disease clinic in the department for advise to local people.

##### SUGGESTED READINGS

1. Neegard P. 1977. Seed Pathology Vol I and II. MacMillan Press, London.
2. Suryanarayan, D. 1978. Seed Pathology. Vikas Publ. House. Pvt. Ltd. New Delhi.
3. Jha, D.K. 1995. A Text Book of Seed Pathology. Vikas Publ. House. Pvt. Ltd. New Delhi.
4. Agarwal, V.K. 1978. Principles of Seed Pathology. In (ed.) James B.S. Srinair, CRC Press. II Edition.
5. Desai, B.B. Seed Handbook. CRC Press.
6. Singh, Gurnam. Seed Pathology. Pointer Publisher, Jaipur.
7. Singh, T. Seed Technology and Seed Pathology. Pointer Publisher, Jaipur.
8. Nene, V.L. and Agarwal, V.K. 1978. Some seed borne diseases and their control. ICAR, New Delhi.

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**Lab Course : BOT40P\***

1. Emasculation, bagging and hand pollination techniques to study pollen germination.
- Application of common plant breeding techniques
2. Floral biology of local food, pulse, vegetable and horticultural crop
3. To test the goodness of fit and independent assortment using Chi-square method
4. To study the pattern of regional biodiversity
5. To study the Hot spots and key stone species
6. Survey of biological resources.
7. Study of habitat loss with respect to plant species. To observe factors expediting habitat loss (i.e., floods, forest fires, landslides, natural and anthropological activities).
8. Visits to national parks, sanctuaries and biosphere reserves of Uttarakhand.
9. Visit to ecosystem restoration sites in mined areas in Uttarakhand Himalayas.
10. PTC - Laboratory organization, different sterilization aseptic technique
11. Preparation and sterilization of media
12. Callus culture (morphological and internal structure) and suspension cultures (growth curve)
13. Shoot tip, axillary bud, nodal explant culture
14. Root tip and leaf culture.
15. Protoplast isolation and fusion
16. Somatic embryogenesis and production of artificial seeds
17. Anther, pollen, ovule culture.

\*Additional lab course of selected elective paper.

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