

DEPARTMENT OF BOTANY AND MICROBIOLOGY

SYLLABUS

M.Sc. (BOTANY)



HNB GARHWAL UNIVERSITY, SRINAGAR-GARHWAL

SYLLABUS

SCHOOL OF LIFE SCIENCES

PROGRAMME- M.Sc. BOTANY

2015-2016 ONWARDS

(Two Year Course- Semester System)

Admission of the Master's Program in Botany shall be through entrance examination conducted by the University and the program shall be based on credit system in which credit defines the quantum of content/ syllabus prescribed for a course system and determines the number of hours of instruction per week.

The student shall be eligible for admission to a Master's Degree Program in Botany after he/she has successfully completed a three year undergraduate degree or earned prescribed number of credits (under CBCS) through the examinations conducted by University as equivalent to an undergraduate degree.

Core courses prescribed for every Semester shall be mandatory for all students registered for the Master's Program in Botany and shall carry minimum 54 credits. Besides this there shall be Elective courses offered in semester III and IV and shall carry a minimum of 18 credits. A self study course would comprise of maximum 09 credits of which one minimum 03 credits shall be mandatory which shall not be included while calculating grades.

Each candidate is expected to participate in the field surveys and excursions required for the Laboratory Courses as and when organized by the Department. Subsequent to that the student would have to present a detailed report of such visits at the time of Semester Practical examination.

In order to qualify for a two year master's degree, a student must acquire a minimum of 72 credits including a minimum of 18 credits in electives choosing at least two elective (leading to a minimum 06 credits) offered by other departments and one qualifying self study course of minimum 03 credits.

Dissertation is an elective one. The dissertation is to be allotted in the beginning of III Semester and would be submitted during the examination of the IV Semester. In lieu of dissertation any two of the given elective papers of 03 credits each and one lab course (of both elective papers) of 03 credits (total 09 credits) may be chosen by those students who

secure less than 75% up to IInd semester level. The Dissertation may be allotted at the start of IIIrd semester to those students who secure 75% or more up to IInd semester level and the Dissertation would be submitted at the time of IV Semester practical examination.

M.Sc. I Semester (July - November)

Code	Paper	Credits				MM
		L	T	P	C	
SLS/BOT/C001	Mycology and Microbiology	3	0	0	3	100
SLS/BOT/C002	Phycology and Bryology	3	0	0	3	100
SLS/BOT/C003	Pteridology, Gymnosperm and Palaeobotany	3	0	0	3	100
SLS/BOT/C004	Taxonomy and Diversity of Flowering Plants	3	0	0	3	100
SLS/BOT/C005	Laboratory Course I	0	0	3	3	100
SLS/BOT/C006	Laboratory Course II	0	0	3	3	100
Total						600

Core Credits = 18

M.Sc. II Semester (December - April)

Code	Paper	Credits				MM
		L	T	P	C	
SLS/BOT/C007	Plant Development and Reproductive Biology	3	0	0	3	100
SLS/BOT/C008	Resource Utilization, IPR and Ethnobotany	3	0	0	3	100
SLS/BOT/C009	Cytogenetics and Molecular Biology	3	0	0	3	100
SLS/BOT/C010	Plant Breeding and Biostatistics	3	0	0	3	100
SLS/BOT/C011	Laboratory Course – I	0	0	3	3	100
SLS/BOT/C012	Laboratory Course – II	0	0	3	3	100
Total						600

Core Credits = 18 with additional 03 Credits of Self Study*

M.Sc. III Semester (July - November)

Code	Paper	Credits				MM
		L	T	P	C	
SLS/BOT/C013	Plant Physiology and Biochemistry	3	0	0	3	100
SLS/BOT/C014	Ecology and Remote Sensing	3	0	0	3	100
SLS/BOT/C015	Laboratory Course – I	0	0	3	3	100
SLS/BOT/E001A	Recombinant DNA Technology	3	0	0	3	100
SLS/BOT/E001B	Forest Ecology	3	0	0	3	100
SLS/BOT/E001C	Natural Resource Management in Himalaya	3	0	0	3	100
SLS/BOT/E001D	Palynology and Pollination Biology	3	0	0	3	100
SLS/BOT/E001E	Any other elective course offered by other department	3	0	0	3	100
SLS/BOT/E002A	Plant Health Management	3	0	0	3	100
SLS/BOT/E002B	Diversity and Cultivation of Mushrooms	3	0	0	3	100
SLS/BOT/E002C	Applied Plant Anatomy	3	0	0	3	100
SLS/BOT/E002D	Ecosystem Analysis, GIS and Remote Sensing	3	0	0	3	100
SLS/BOT/E002E	Any other elective course offered by other department	3	0	0	3	100
SLS/BOT/E003	Laboratory Course – II	0	0	3	3	100
Total						600

Total Credits = 18 (Core Credits 09+ Elective Credits 09) with additional 03 Credits of Self Study*

M.Sc. IV Semester (December - April)

Code	Paper	Credits				MM
		L	T	P	C	
SLS/BOT/C016	Conservation Biology	3	0	0	3	100
SLS/BOT/C017	Biotechnology and Genetic Engineering of Plants and Microbes	3	0	0	3	100
SLS/BOT/C018	Laboratory Course – I	0	0	3	3	100
SLS/BOT/E004	Dissertation	0	0	9	9	300
Total						600

Dissertation/ Project Work

Anatomy of Himalayan woods

Chromosome Analysis and Indexing of Himalayan Flora

Conservation of endangered species

Environment Impact Assessment

High altitude Ecology and Climate Change

Invasion Ecology

Inventorization of unexplored Areas and Hotspots

Limnology

Plant Biodiversity Assessment

Pollution Monitoring

Population/weed/ Reproductive Biology

Survey of Less known Economic Plants

Any other current trends / topics suggested by the Departmental committee

The distribution of marks for the Dissertation will be as below:

Periodical Presentation	: 60 Marks
Dissertation	: 180 Marks
Viva Voce	: 60 Marks
Total	: 300 Marks

The dissertation/ project report shall be evaluated jointly by the supervisor and one external examiner.

In lieu of dissertation any two of the following papers with their practical (03 credit each) can be opted .

Code	Paper	Credits				MM
		L	T	P	C	
SLS/BOT/E005A	XXIIb. Propagation Techniques	3	0	0	3	100
SLS/BOT/E005B	XXIIc. Environment Management with Reference to Western Himalaya.	3	0	0	3	100
SLS/BOT/E005C	XXIIId. Bioinformatics and Biological Database	3	0	0	3	100
SLS/BOT/E005D	XXIIe. Seed Pathology	3	0	0	3	100
SLS/BOT/E006	Laboratory Course – II	0	0	3	3	100
(Any two papers and their Lab. Course)					Total	300

Total Credits = 18 (Core Credits 09+ Elective Credits 09) with additional 03 Credits of Self Study*

Grand Total: Core Credits 54+ Elective Credits 18= 72

With a total of 09 Credits (3+3+3 Credits in II, III and IV semester) of Self Study (2 Seminars equivalent to 2 sessionals plus one end term written examination).

Maximum Marks for each paper is 100 (Sessional Tests- 40 + End Term Test- 60).

01 Credit= 01 hour of lecture/instructions per week; 01 Credit course= 15 hours of lectures per semester.

03 hours of laboratory course shall be considered equivalent to 01 hour of lecture.

The 2- Year Masters Programme will have the following components:

1. **Core course:** Minimum 54 credits.

2. **Elective course:** Minimum 18 credits choosing at least two Electives (leading to a minimum 06 credits) in Semester III offered either by the parent department or other departments and one Elective course as Dissertation (09 credits) in IV Semester.

3. **Self study course:** Maximum 09 credits (one minimum 03 credits shall be mandatory but not to be included while calculating grades).

SLS/BOT/C001. Paper I: MYCOLOGY AND MICROBIOLOGY

MYCOLOGY

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); Recent trends in the classification.
3. Phylogeny of Fungi; General account of *Mastigomycotina*, *Zygomycotina*, *Ascomycotina*, *Basidiomycotina*, *Deuteromycotina*; Fungi in industry, medicine and as food. Mycorrhizae; Fungi as biocontrol agents.
4. Symptoms, causal organisms of plant pathogens belonging to various fungal classes i.e. *Mastigomycotina*, *Zygomycotina*, *Ascomycotina*, *Basidiomycotina* and *Deuteromycotina*.

MICROBIOLOGY

5. A brief history of Microbiology, the diversity of micro-organisms, microbial growth.
6. Archaeobacteria and Eubacteria: General account; ultrastructure, nutrition and reproduction; biology and economic importance; cyanobacteria- classification, salient features and economic importance.
7. Viruses: Characteristics; isolation and purification of viruses; chemical nature, replication, Transmission of viruses; economic importance.
8. Phytoplasma: General characteristics and role in causing plant diseases. (e.g. sandal spike disease, sesame phyllody, little leaf of brinjal)
9. Immunology: Structure of antigens and antibodies, antigen- antibody reaction, , Mechanism of antigen-antibody reactions. Vaccines and toxoids, Hypersensitivity

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 Aneja, R.S. 1998. An Introduction to Mycology. New Age Intermediate Press.
7. Webster, J. 1985. Introduction to Fungi. Cambridge University Press.
8. Doelle, H.W. and C.G, Heden 1986. Applied Microbiology, Kluwer Academic Press, London.
9. Pelczar, M.J., Chan, ECS and Kreig, N.R. 1993. Microbiology, Concept and Applications. McGraw Hill, New York.
10. Ross, F.C. 1983. Introductory Microbiology. Charles E. Merrill. Publ. Co. Columbus, Ohio.
11. Alexander, M. 1991. Microbial Ecology. John Wiley and Sons. New York.

12. APHA. 1971. Standard Methods for the Examination of water and Waste Water. Washington DC
13. Atlas. R. M. Principle of Microbiology.
14. Board, R.G. and D.W., Lovelock 1975. Some Method for Microbiological Assay. Academic Press. New York
15. Casida, L.E. 1968. Industrial Microbiology. John Wiley and Sons, New York.
16. Clifford, H.T. and W. Stephenson 1975. An Introduction to Numerical Classification, Academic press, New York.
17. Doelle, H.W. and C.G., Heden 1986. Applied Microbiology. Kluwer Acad. Press, London.
18. Kaushik, P. 1996. Introductory Microbiology. Emkay Publ, Delhi.
19. Miller, B.M. and W. Litsky 1976. Industrial Microbiology. Mc Graw Hill New York.
20. Mukherjee, K.G. and Ved Pal Singh, 1997. Frontiers in Applied Microbiology. Rastogi Publ. Meerut.
21. Norris, J.R. and D.W. Ribbons 1970. Methods in Microbiology. Academic Press, London.
22. Power, C.B. and H.F. Dagainawala 1996. General Microbiology 2 Vols. Himalaya Pub. House, New Delhi.
23. Ross, F.C. 1983. Introductory Microbiology. Charles E. Merrill Publ. Co. Columbus. Ohio.

SLS/BOT/C002. Paper II: PHYCOLOGY AND BRYOLOGY

PHYCOLOGY

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.
5. Classification and salient features of Chlorophyta, Charophyta, Xanthophyta, Bacillariophyta, Phaeophyta, Rhodophyta and Cyanophyta.
6. A knowledge of algal life cycles; alternation of generation in algae; cytology and sexuality; physiology and biochemistry of algae; nitrogen fixation; parasitic algae.
7. Economic importance of Algae, Algal blooms, algal biofertilizers, algae as food, feed and uses in industry.

BRYOLOGY

8. Morphology, structure reproduction and life history.
9. Classification and Phylogeny of various groups.
10. General account of Marchantiales, Jungermanniales, Calobryales, Sphaerocarpaceae, and Anthocerotales.
11. Sphagnales, Andreales, Funariales, and Polytrichales.

12. Knowledge of the distribution of bryophytes in the Himalaya. Ecology of bryophytes, their association with other organisms.
13. 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 Delhl.
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. Presscott, 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.

SLS/BOT/C003. Paper III: PTERIDOLOGY, GYMNOSPERMS AND PALAEOBOTANY

PTERIDOPHYTA

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 Hyeniales, Sphenophyllales and Calamitales
 - d. Pterophyta: A general account of Ophioglossales Osmundales Filicales, and Salviniales .

GYMNOSPERMS

1. Classification and distribution of Gymnosperms in India with special reference to Himalaya. Study of their morphology, structure and life-history as illustrated by the following and indicated in the practical work.
 - e. Pteridospermales: Palaeozoic and Mesozoic groups with references to Lyginopteridaceae (*Lyginopteris*) and Medullosaceae (*Trigonocarpus*), A general account of Glossopteridaceae.
 - f. Bennettiales: A general account of Cycadeoidaceae, Williamsoniaceae and Wielandiellaceae.
 - g. Cycadales: A detailed account including distribution of living Cycads.
 - h. A general account of Pentoxylales and Cordaitales.
 - i. Ginkgoales: *Ginkgo*.
 - j. A general account of fossil and living Coniferales and Taxales.
 - k. Ephedrales, Welwitschiales and Gnetales: A general account.

2. Economic importance of Gymnosperms.

PALAEOBOTANY

3. Definition of fossil, different types of plant fossil as per their mode of preservation, concept of form genus.
4. Indian Gondwana Sequence, a general account.
5. 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.
12. Sporne, K.R. 1991. The Morphology of Gymnosperms. Hutchinson Library Series London.

SLS/BOT/C004. Paper IV: TAXONOMY AND DIVERSITY OF FLOWERING PLANTS

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.
3. Salient features of the International Code of Botanical Nomenclature.
4. Taxonomic evidences and Taxonomic tools: anatomy, palynology, embryology, phytochemistry, histological, cytological, phytochemical, serological, biochemical and molecular techniques.
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. Herbarium and Botanical gardens: General account.
7. Plant exploration in India with reference to North west and Uttarakhand Himalaya
8. Status of flowering plant diversity in Garhwal Himalaya.

9. A study of the following families and their relationships:
- a. Dicotyledons: Magnoliaceae, Berberidaceae, Fumariaceae, Violaceae, Meliaceae, Apiaceae, Sterculiaceae, Tiliaceae, Geraniaceae, Combretaceae, Asteraceae, Campanulaceae, Ericaceae, Primulaceae, Asclepiadaceae, Convolvulaceae, Verbenaceae, Scrophulariaceae, Oleaceae, , Amaranthaceae, Chenopodiaceae, Loranthaceae, Urticaceae, Juglandaceae, Fagaceae and Salicaceae.
 - b. Monocotyledons: Hydrocharitaceae, Orchidaceae, Amaryllidaceae, Arecaceae, Araceae, Lemnaceae, Poaceae and Cyperaceae .

Besides these families, the students are also expected to have a complete knowledge of families which they have studied at under graduate syllabus of this University.

SUGGESTED READINGS

1. Babu, C.R. 1976. Herbaceous Flora of Dehradun. CSIR, New Delhi.
2. Cole, A.J. 1969. Numerical Taxonomy, Academic Press, London.
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.
16. Nordenstam, B., El Gazaly, G. and Kassas, M. 2000. Plant Systematic for 21st Century. Portlant Press Ltd., London.
17. Radford, A.E. 1986. Fundamentals of Plant Systematics. Harper & Row Publications, USA.
18. Singh, H. 1978. Embryology of Gymnosperms. Encyclopaedia of Plant Anatomy X. Gebruder Bortraeger, Berlin.

18. Solbrig, O.T. 1970. Principles and Methods of Plant biosystematics. The MacMillan Co. - Collier- MacMillan Ltd., London.
19. Solbrig, O.T. and Solbrig, D.J. 1979. Population Biology and Evolution. Addison- Wesley Publication Co. Inc., USA.
20. Stace, C.A. 1989. Plant Taxonomy and Biosystematics. Edward Arnold, London.
21. Stebbins, G.L. 1974. Flowering Plant- Evolution above Species Level. Edward Arnold Ltd., London.
22. Stace, C.A. 1989. Plant Taxonomy and Biosystematics (2nd edition). Edward Arnold Ltd., London.
23. Takhtajan, A.L. 1997. Diversity and Classification of Flowering Plants. Columbia University Press, New York.
24. Woodland, D.W. 1991. Contemporary Plant Systematics. Prentice Hall, New Jersey.

SLS/BOT/C005 PaperV LABORATORY COURSE I

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*, *Cylindrospermum*, *Gloeotrichia*, *Scytonema*, *Pandorina*, *Eudorina*, *Scenedesmus*, *Pediastrum*, *Hydrodictyon*, *Ulva*, *Enteromorpha*, *Draparnaldiopsis*, *Stigeoclonium*, *Fritschiella*, *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*,

SLS/BOT/C006 Paper VI LABORATORY COURSE II

Study and identification with suitable preparations of the following:

A. PTERIDOPHYTES

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

B. GYMNOSPERMS

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

C. PALAEOBOTANY

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

D. TAXONOMY

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.

SEMESTER II

SLS/BOT/C007. Paper VII: PLANT DEVELOPMENT AND REPRODUCTIVE BIOLOGY

1. Seed germination and seedling growth: Mobilization of food reserves; tropisms; hormonal control of seedling growth.
2. Shoot development: Organization of the shoot apical meristem (SAM); cytological and molecular analysis of SAM; control of cell division and cell to cell communication.
3. Cambium and its functions: formation of secondary xylem; general account of wood structure in relation to conduction of water and minerals.
4. Leaf growth and differentiation: Origin, development and phyllotaxy.
5. Root development: Organization of root apical meristem (RAM); cell fates and lineages; vascular tissue differentiation; lateral roots; root hairs; root-microbe interactions.
6. Reproduction: Vegetative options and sexual reproduction; flower- a modified shoot, structure, functions; structure of anther and pistil; Genetics of floral organ differentiation.
7. Male gametophyte: Structure of anthers; microsporogenesis, role of tapetum; pollen development and gene expression.
8. Female gametophyte: Ovule development; megasporogenesis; organization of the embryo sac .
9. Pollination, pollen-pistil interaction and fertilization: Pollen-stigma interactions, sporophytic and gametophytes self-incompatibility (cytological, biochemical and molecular aspects); double fertilization; *in vitro* fertilization.
10. Seed development and Fruit growth: Endosperm development ; embryogenesis, polyembryony; apomixis; embryo culture; biochemistry and molecular biology of fruit maturation.
11. Latent life–Dormancy: Importance and types of dormancy; seed dormancy; overcoming seed dormancy; bud dormancy.
12. Senescence and programmed cell death (PCD): Basic concept, types of cell death, PCD in the life cycle of plant, metabolic change associated with senescence and its regulation; influence of hormones and environmental factors on senescence.

SUGGESTED READINGS:

1. Atwell, B.J., Kriedermann, P.E. and Jurnbull, C.G.N. (Eds) 1999. Plants in Action: Adaptation in Nature, Performance in Cultivation. MacMillan education, Sydney, Australia.
2. Bewley, J.D. and Black, M. 1994. Seeds: Physiology of Development and Germination. Plenum Press, New York.
3. Bhojwani, S.S. and Bhatnagar, S.P. 2000. The Embryology of Angiosperms (4th revised and enlarged edition). Vikas Publishing House, New Delhi.
4. Burgess, J. 1985. An Introduction to Plant Cell Development. Cambridge University Press, Cambridge.
5. Chopra, V.L. 2001. Plant Breeding: Theory and Practice. Oxford & IBH Pvt. Ltd., New Delhi.

6. Chopra, V.L. 2001. Plant Breeding: Field Crops. Oxford & IBH Pvt. Ltd., New Delhi.
7. Eams, A.J. 1989. An Introduction to Plant Anatomy. Reprint. Bishen Singh Mahendra Pal Singh, Dehradun.
8. Fageri, K. and Van der Pijl, L. 1979. The Principles of Pollination Ecology. Pergamon Press, Oxford.
9. Fahn, A. 1982. Plant Anatomy. (4th edition). Pergamon Press, Oxford.
10. Fosket, D.E. 1994. Plant Growth and Development. A Molecular Approach. Academic Press, San Diego.
11. Howell, S.H. 1998. Molecular Genetics of Plant Development. Cambridge University Press, Cambridge.
12. Leins, P., Tucker, S.C. and Endress, P.K. 1988. Aspects of Floral Development. *J. Cramer*, Germany.
13. Lyndon, R.F. 1990. Plant Development. The Cellular Basis. Unwin Hyman, London.
14. Maheshwari, P. 1950. An Introduction to Embryology of Angiosperms. McGraw Hill, New York.
15. Metcalf, C.R. and Chalk, L. 1983. Anatomy of Dicotyledons and Monocotyledons. 2 Vols. Clarendon Press, Oxford.
16. Murphy, T.M. and Thompson, W.F. 1988. Molecular Plant Development. Prentice Hall, New Jersey.
17. Proctor, M. and Yeo, P. 1973. The Pollination of Flowers. William Collins Sons, London.
18. Raghavan, V. 1997. Molecular Embryology of Flowering Plants. Cambridge University Press, Cambridge.
19. Raghavan, V. 1999. Developmental Biology of Flowering Plants. Springer-Verlag, New York.
20. Raven, P.H., Evert, R.F. and Eichhorn, S.E. 1992. Biology of Plants (5th edition). Worth, New York.
21. Salisbury, F.B. and Ross, C.W. 1992. Plant Physiology (4th edition). Wadsworth Publishing, Belmont, California.
22. Steeves, T.A. and Sussex, I.M. 1989. Patterns in Plant Development (2nd edition) Cambridge University Press, Cambridge.
23. Sedgely, M. and Griffin, A.R. 1989. Sexual Reproduction of Tree Crops. Academic Press, London.
24. Shivanna, K.R. and Sawhney, V.K. (eds) 1997. Pollen Biotechnology for Crop Production and Improvement. Cambridge University Press, Cambridge.
25. Shivanna, K.R. and Rangaswamy, N.S. 1992. Pollen Biology: A Laboratory Manual. Springer-Verlag, Berlin.
26. Shivanna, K.R. and Johri, B.M. 1985. The Angiosperm Pollen: Structure and Function. Wiley Eastern Ltd., New York.
27. The American Society of Plant Physiologists 1993. The Plant Cell. Special Issue on Reproductive Biology of Plants, Vol. 5 (10), Rockville, Maryland, USA.
28. Thorpe, T.A. 1996. In vitro Embryogenesis in Plants. Kluwer Academic Publ. London.

SLS/BOT/C008. Paper VIII: RESOURCE UTILIZATION, IPR AND ETHNOBOTANY

1. Plant resources: Concept, status, utilization and concerns.
2. World Centers of Primary Diversity of domesticated plants
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.
4. Fiber crops, medicinal and aromatic.
5. Important firewood and timber yielding plants and non- wood forest products (NWFPs) such as bamboos, gums, tannins, dyes, resins, beverages.
6. Intellectual Property Rights, Concept, History, Protection of IPR; Patent- requirements, procedures and limitations; International convention on Biological Diversity.
7. Ethnobotany: Concept, linkage with other sciences, tools of ethnobotanical studies, world and Indian perspective with special reference to the Himalayas.
8. Green revolution: Benefits and adverse consequences.
9. Plants used as ornamentals and avenue trees.
10. Principles of conservation: Extinction ; Status of plants based on International Union for Conservation of Nature (IUCN).
11. Strategies for conservation: *In situ* conservation; Protected areas in India- sanctuaries, national parks and biosphere reserves.

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. Chandel, 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. 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.

SLS/BOT/C009. Paper IX: CYTOGENETICS AND MOLECULAR BIOLOGY

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.
5. Nucleus: structure, nuclear pores, nucleosome organization.
6. Ribosomes: Structure, cytoprotein synthesis.

7. 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.
8. Principles of inheritance: Mendelian laws along with molecular explanations, Exceptions to Mendelian laws, lethal alleles and Gene Interactions.
9. Structural and numerical alterations in chromosomes: Origin, occurrence, production and meiosis of haploids, aneuploids and euploids, induction and characterization of trisomics and monosomics.
10. Genetics of prokaryotes and eukaryotic organelles: genetic recombination of phage; genetic transportation, conjugation and transduction in bacteria, cytoplasmic male sterility.
11. 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.
12. Genetic recombination and genetic mapping: Recombination; independent assortment and crossing over, linkage groups, genetic markers, construction of molecular maps.
13. Mutations: Spontaneous and induced mutations; physical and chemical mutation, molecular basis of gene mutation; mutations induced by transposons.
14. 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
2. Biology of the Cell (2nd edition). Garland Publishing Inc., New York.
3. Atherly, A.G., Girton, J.R. and McDonald, J.F. 1999. The Science of Genetics. Saunders College Publishing, Fort Worth, USA.
4. Burnham, C.R. 1962. Discussions in Cytogenetics. Burgess Publishing Co., Minnesota.
5. Busch, H. and Rothblum, L. 1982. Volume X. The Cell Nucleus rDNA Part A. Academic
6. Press.
7. Barry, J.M. and Barry, B.M. 1973. Molecular Biology, Prentice Hall Of India
8. New Delhi.
9. Buchanan, B.B., Gruissem, W. and Jones, R.L. 2000. Biochemistry and Molecular Biology of Plants. American Society of Plant Physiologists, Maryland, USA.
10. De, D.N. 2000. Plant Cell Vacuoles: An Introduction. CSIRO Publication, Collingwood, Australia.
11. Gupta, P.K. 1998. Cytogenetics. Rastogi Publications. Meerut.
12. Hartl, D.L. and Jones, E.W. 1998. Genetics: Principles and Analysis (4th edition). Jones & Bartlett Publishers, Massachusetts, USA.
13. Kleinsmith, L.J. and Kish, V.M. 1995. Principles of cell and Molecular Biology (2nd Edition). Harper Collins College Publishers, New York, USA.
14. Krishnamurthy, K.V. 2000. Methods in Cell wall Cytochemistry. CRC Press, Boca Raton, Florida.
15. Lewin, B. 2000. Genes VII. Oxford University Press, New York.
16. 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
17. Malacinski, G.M. and Freifelder, D. 1998. Essentials of Molecular Biology (3rd
18. edition). Jones and Bartlet Publishers, Inc., London.

19. Stent, G.S. 1986. Molecular Genetics. Bishen Singh Mahendra Pal Singh, Dehradun.
20. Watson, J.D. 1965. Molecular Biology of the Gene. Benjamin.
21. Wolfe, S.L. 1993. Molecular and Cellular Biology. Wadsworth Publishing Co. California, USA.

SLS/BOT/C010. Paper X PLANT BREEDING AND BIOSTATISTICS

PLANT BREEDING

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

BIOSTATISTICS

1. Bio-statistics and its application in life sciences.
2. Methods of representation of statistical data and measurements of central tendencies.
3. Correlation, regression, curve fitting and ratio of variation.
4. Probability and use of binomial trials.
5. Test of significance, X^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. Mc Donald, 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. Poelhman, J.M and Sleeper, D.R. 1995. Breeding Field Crops. Panima 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. Peitermaritzburg. 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.
7. New York.

SLS/BOT/C011 Paper XI LABORATORY COURSE I

- a. Effect of gravity, unilateral light and plant growth regulators on the growth of young seedlings.
- b. Role of dark and red light / far red light on the expansion of cotyledons and epicotylar hook opening in pea.
- c. Study of cytohistological zones in the shoot apical meristem (SAM) in sectioned and double stained slides of suitable plants such as *Coleus*, *Kalanchoe*, *Nicotiana*. Examination in shoot apices in a monocot both in T. S. and L. S. to show the origin of leaf primordia.
- d. Study of alternate and distichous, alternate and superposed, opposite and superposed opposite and decussate leaf arrangement. Examination of rosette plants (*Launaea*, *Mollugo*, *Raphanus*, *Hyoscyamus*, etc.) and induction of bolting under natural conditions as well as GA treatment.
- e. 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 C3 and C4 plants.
- f. Study of epidermal peels of leaves to study the development and final structure of stomata and prepare stomatal index. Demonstration of the effect of ABA on stomatal closure.
- g. Study the whole roots of dicots and monocots. Examination of root apical meristem and its derivatives (using maize, aerial roots of banyan, etc.). Study of lateral roots. Study of lateral roots with different types of nodules.
- h. Study of microsporogenesis and gametogenesis in sections of anthers.
 - i. 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).

- ii. Tests for pollen viability using stains and *in vitro* germination. Pollen germination using hanging drop and sitting drop cultures.
 - iii. Pollen storage, pollen–pistil interaction, self-incompatibility, *in vitro* pollination.
 - iv. Study of ovules in cleared preparations. Study of monosporic, bisporic and tetrasporic types of embryo sac development through permanent slides.
 - v. Field study of types of flowers with different pollination mechanisms (wind pollination, insect pollination, etc.).
 - vi. Emasculation, bagging and hand pollination techniques to study pollen germination.
- Study of seed dormancy and methods to break dormancy.

- i. The practical course of this section is divided into three units: (1) Laboratory work, (2) Field survey and (3) Scientific visits
 - i. Food crops: wheat, rice, maize, chickpea, potato, tapioca, sweet potato, sugarcane; morphology, anatomy and micro chemical tests for stored food materials.
 - ii. Forage/fodder plants: Study of ten important fodder crops of the locality.
 - iii. 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.
 - iv. Medicinal and aromatic plants including narcotics and antibiotics.
 - v. Vegetable oils: Mustard, groundnut, soybean, coconut, sunflower and castor. Morphology, microscopic structure of oil yielding tissues, test for oil and iodine number.
 - vi. To prepare a water extract of vegetable tannins (*Acacia*, *Terminalia*, *Camellia*, *Cassia*) and dyes (*Curcuma longa*, *Bixa orellana*, *Indigofera*, *Butea monosperma*, *Lawsonia inermis*, etc.).

SLS/BOT/C012 Paper XII LABORATORY COURSE II

- 1. Study of mitotic chromosomes in root tips and leaf buds and meiotic chromosomes in floral buds.

2. Isolation of chloroplasts and SDS-PAGE profile of proteins to demarcate the two subunits of Rubisco.
 3. Isolation of DNA and preparation of 'cot' curves.
 4. Restriction digestion of plant DNA, its separation by agarose gel electrophoresis and visualization by ethidium bromide staining.
 5. Isolation of RNA and quantitation by spectrophotometric method.
 6. Southern blot analysis using a gene specific probe.
 7. Northern blot analysis using a gene specific probe.
 8. Western blotting and ELISA.
 9. Genetical problems on Mendelian and post-Mendelian ratios, gene interactions, sex-linked inheritance, chromosomal mapping, etc.
 10. Application of common plant breeding techniques
 11. Identification of Indian varieties of important crops.
 12. Floral biology of local food, pulse, vegetable and horticultural crops.
 13. Collection of germplasm of different crops being grown in the area.
 13. Study of techniques of biometrical studies.
14. To test the goodness of fit and independent assortment using Chi-square method.

Manuals for Laboratory Exercises.

Fakui, K. and Nakayama, S. 1996. Plant Chromosomes: Laboratory Methods. CRC Press, Boca Raton, Florida.

Glick, B.R. and Thompson, J.E. 1993. Methods in Plant Molecular Biology and Biotechnology. CRC Press, Boca Raton, Florida.

Hackett, P.B., Fuchs, J.A. and Messing, J.W. 1988. An Introduction to Recombinant DNA Techniques: Basic Experiments in Gene Manipulation. The Benjamin/Cummings Publishing Co., Inc Menlo Park, California.

Hall, J.L. and Moore, A.L. 1983. Isolation of Membranes and Organelles from Plant Cells. Academic Press, London, UK.

Harris, N. and Oparka, K.J. 1994. Plant Cell Biology: A Practical approach. IRL Press, at Oxford University Press, Oxford, U.K.

Shaw, C.H. (Ed.), 1988. Plant Molecular Biology: A Practical Approach. IRL Press, Oxford.

Snustad, D.P. and Simmons, M.J. 2000. Principles of Genetics (2nd edition). John Wiley & Sons Inc., USA.

Sharma, A.K. and Sharma, A. 1999. Plant chromosomes: Analysis, Manipulation and Engineering. Harwood academic Publishers, Australia.

Semester III

SLS/BOT/C013: PLANT PHYSIOLOGY AND BIOCHEMISTRY

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.
3. 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.
4. Membrane transport and translocation of water and solutes: Plant-water relations, mechanism of water transport through xylem and transport in cells. Absorption and transpiration of water.
5. Photophysiology and photosynthesis: General concepts and historical background, evolution of photosynthetic apparatus, photosynthetic pigments and light harvesting complexes, photo oxidation of water, light reaction, Z scheme and photophosphorylation, mechanism of electron transport, carbon assimilation – the Calvin cycle, photorespiration and its significance, the C₄ cycle, the CAM pathway, factors of photosynthesis.
6. Respiration and lipid metabolism: Overview of plant respiration, glycolysis, the TCA cycle, electron transport and ATP synthesis, pentose phosphate pathway, glyoxylate cycle, alternative oxidation system, photorespiration.
7. Nitrogen fixation, nitrogen and sulphur metabolism: Overview, biological nitrogen fixation, nodule formation and nod factors, mechanism of nitrate uptake and assimilation, sulfur uptake, transport and assimilation.
8. Phytohormones and Sensory photobiology: History of discovery of phytochromes and cryptochromes, and their photochemical and biochemical properties, photophysiology of light-induced responses, molecular mechanism of action of photomorphogenic receptors, signaling and gene expression.

SUGGESTED READINGS:

1. Buchanan, B.B., Gruissem, W. and Jones, R.L. 2000. Biochemistry and Molecular Biology of Plants. American Society of Plant Physiologists, Maryland, USA.
2. Dennis, D.T., Turpin, D.H., Lefebvre, D.D. and Layzell, D.B. (eds) 1997. Plant Metabolism (second edition). Longman, Essex, England.
3. Hooykaas, P.J.J., Hall, M.A. and Libbenga, K.R. (eds) 1999. Biochemistry and Molecular Biology of Plant Hormones. Elsevier, Amsterdam, The Netherlands.
4. Hopkins, W.G. 1995. Introduction to Plant Physiology. John Wiley & Sons, Inc., New York, USA.
5. Lodish, H., Berk, A., Zipursky, S.L., Maztsudaira, P., Baltimore, D. and Darnell, J.2000. Molecular Cell Biology (4th edition). W.H. Freeman and Company, New York, USA.
6. Moore, T.C. 1989. Biochemistry and Physiology of Plant Hormones (second edition). Springer-Verlag. New York USA.

7. Nobel, P.S. 1999. *Physiochemical and Environmental Plant Physiology* (Second edition). Academic Press, San Diego, USA.
8. Noggle, G.R and Fritz, G.F. 1977. *Introductory Plant Physiology*. Prentice Hall. New Delhi.
9. Salisbury, F.B. and Ross, C.W. 1992. *Plant Physiology* (4th edition). Wadsworth Publishing Co., California, USA.
10. Singhal, G.S., Renger, G., Sopory, S.K., Irrgang, K.D. and Govindjee 1999. *Concepts in Photobiology: Photosynthesis and Photomorphogenesis*. Narosa Publishing House, New Delhi.
11. Taiz, L. and Zeiger, E. 1998. *Plant Physiology* (2nd edition). Sinauer Associates, Inc., Publishers, Massachusetts, USA.
12. Thomas, B. and Vince-Prue, D. (1997) *Photoperiodism in Plants* (Second edition). Academic Press, San Diego, USA.

SLS/BOT/C014. Paper XIV ECOLOGY AND REMOTE SENSING

1. Vegetation organization: Concepts of community and continuum; analysis of communities (analytical and synthetic characters); community coefficient; interspecific associations; ordination; concept of ecological niche.
2. Vegetation development: Temporal changes (cyclic and non cyclic); mechanism of ecological succession (relay floristics and initial floristic composition; Facilitation, tolerance and inhibition models); changes in ecosystem properties during succession.
3. Ecosystem organization: Structure and functions; primary production (methods of measurement, global pattern, controlling factors); energy dynamics (trophic organization, energy flow pathways, ecological efficiencies); litter fall and decomposition (mechanism, substrate quality and climatic factors),
4. global biogeochemical cycles of C, N, P and S; mineral cycle (pathways, processes, budgets) in terrestrial ecosystems.
5. Ecosystem stability: Concept (resistance and resilience); ecological perturbation (natural and anthropogenic) and their impact on plants and ecosystems; ecology of plant invasion; environmental impact assessment; ecosystem restoration.
6. Biological diversity: Concepts and levels; role of biodiversity in ecosystem functions and stability; speciation and extinction; IUCN categories of threat; distribution in global patterns; terrestrial biodiversity hot spots; inventory.
7. Climate, and vegetation pattern of the world: Life zones; major biomes, and major vegetations.
8. Soil : Definition, formation, profile and components and soil types of the world.
7. Air, water and soil pollution: Kinds; sources; quality parameters; effects on plants and ecosystems.
8. Climate change: Greenhouse gases (CO₂, CH₄, N₂O, CFCs; sources, trends and role); Ozone layer and ozone hole; consequences of climate changes (CO₂ fertilization, global warming, sea level rise, UV radiation).

9. Fire as an ecological factor: Types, role of fire, extent and causes of fire in forest, grasslands and in tropical savanna, fuel load, controlled burning, fire in different forest types in Uttaranchal; fire as management tool.
10. Ecological management: Concept; sustainable development, sustainability indicators.
11. Remote Sensing: Concepts and stages in the acquisition of remote sensing data; Spectral signature, Photographic and non photographic sensors, Space Plat forms.
12. Basic principles of Photogrammetry and Photo interpretation.
13. Application of remote sensing in ecological and forestry research.

SUGGESTED READINGS:

- a. Barbour, M.G., Burk, J.H. and Pitts, W.D. 1987. Terrestrial Plant Ecology. Benjamin/Cummings Publication Company, California
- b. Begon, M., Harpor, J.L. and Townsend, C.R. 1996. Ecology. Blackwell Science, Cambridge, U.S.A.
- c. Chapman, J.L. and Reiss, M.J. 1988. Ecology: Principles and Applications. Cambridge University Press, Cambridge, U.K.
- d. Heywood, V.H. and Watson, R.T.1995. Global Biodiversity Assesment. Cambridge University Press.
- e. Kershaw, K.A. Quantitative and Dynamic Ecology. Oxford and IBH. Kormondy, E.J. 1996. Concepts of Ecology. Prentice-Hall of India Pvt. Ltd., New Delhi.
- f. Odum, E.P. 1983. Basic Ecology. Saunders, Philadelphia
- g. Smith, R.L. 1996. Ecology and Field Biology. Harper Collins, New York.

SLS/BOT/C015 LABORATORY COURSE I

A. Practical Exercises based on SLS/BOT/C013

1. To study the effect of temperature upon the permeability of the cytoplasmic membrane.
2. To determine the osmotic pressure (potential) of cell saps of living cells by plasmolytic method and also by using KNO_3 and sugar solution and to calculate the isotonic coefficient of sugar.
3. To determine the diffusion pressure deficit of plant cells.
4. To set up a Wilmott's bubbler and to study the effect of the following on the rate of photosynthesis (a) varying CO_2 concentration and (b) different wavelengths of light.
5. To extract the four pigments i.e. chlorophyll a & b, carotene and ~~xanthophylls~~ from the green leaves and preparation of their absorption spectrum.
6. To separate the four pigments i.e. chlorophyll a & b, carotene and xanthophylls from the green leaves by paper chromatography and column chromatography.
7. To separate the amino acids by paper chromatography.
8. Principles of colorimetry, spectrophotometry and flourimetry.

B. Practical Exercises based on SLS/BOT/C014

1. To determine the minimum size of the quadrat by species area curve method and minimum number of quadrats to be laid down in the field under study.
2. To determine the frequency, density and abundance of each species present in community.
3. To calculate relative frequency and relative density of each species in a given area.
4. To calculate mean basal cover and total basal cover of each species in a given area.
5. To compute the relative dominance and IVI (Importance Value Index) of each species in a given area.
6. To calculate the Alpha (∞) diversity, Beta (β) diversity and total diversity of given community.
7. To calculate water holding capacity of three samples of various soil types and to find the percolation percentage of water in the given soil.
8. To find out the bulk density and porosity of different soil types
9. Stereo test.
10. To test the pH and the buffering properties of soils.
11. Study of types of aerial photos and satellite data products.
12. Orientation of stereo model under mirror stereoscope.

Suggested Manuals for Physiological Exercises

1. Bajracharya, D. 1999. Experiments in Plant Physiology: A Laboratory Manual. Narosa Publishing House, New Delhi.
2. Copeland, R.A. 1996. Enzymes: A Practical Introduction to Structure, Mechanism and Data Analysis. VCH Publishers, New York.
3. Dryer, R.L. and Lata, G.F. 1989. Experimental Biochemistry. Oxford University Press, New York.
4. Harborne, T.C. (1981). Phytochemical Methods: A Guide to Modern Techniques of Plant Analysis. Chapman & Hall, London.
5. Ninfa, A.J. and Ballou, D.P. 1998. Fundamental Laboratory approaches for Biochemistry and Biotechnology. Fitzgerald Science Press, Inc., Maryland, USA.
6. Plummer, D.T. 1988. An Introduction to Practical Biochemistry. Tata McGraw- Hill Publishing co. Ltd., New Delhi.

Suggested Manuals for Ecological Exercises:

1. APHA- Standard Methods for the Examination of Water and Waste Water. American Public Health Association, Washington, DC.
2. Downie, N.M. and Heath, R.W. 1988. Basic Statistical Methods.
3. Kapoor /Govil. 2000. Experimental Plant Ecology.
4. Krebs, C.J. 1989. Ecological Methodology. Harper and Row, New York, USA.
5. Misra, R. 1968. Ecology Work Book. Oxford & IBH New Delhi.
6. Moore, P.W. and Chapman, S.B. 1986. Methods in Plant Ecology. Blackwell Scientific Publications
7. Pielou, E.C. 1984. The Interpretation of Ecological Data. Wiley New York.

SLS/BOT/E001A RECOMBINANT DNA TECHNOLOGY

1. Scope of rDNA technology in various sectors, Vehicles: Plasmid and Bacteriophage; Purification of DNA: total DNA, plasmid DNA and bacteriophage DNA; enzymes used in manipulation of purified DNA.
2. Cloning vectors based on *E. coli* plasmids, cloning vectors based on M13 bacteriophage and λ bacteriophage, vectors for genomic library construction, vectors for other bacteria. Vectors for yeasts and other fungi, higher plants, animal cells.
3. Rationale for the design of vectors for the over expression of recombinant proteins
4. Selection of suitable promoter sequences, ribosome binding sites, transcription terminator, fusion protein tags, purification tags, protease cleavage sites and enzymes, plasmid copy number, inducible expression system, promoter probe vectors.
5. Experiments using model systems: *E. coli*, *Yeast*, *Baculovirus*, *Agrobacterium tumifaciens*.
6. Basic idea of transformation, conjugation and transduction. Introduction of DNA into host cells.
7. Transformation and identification of recombinants, transfection and identification of recombinants, transformation of non-bacterial cells.
8. Obtaining clone of a specific gene: the problem of selection, direct selection, methods of identification of clone from gene library.
9. Locating the cloned gene in plasmid and in chromosomes using southern hybridization and chromosome walking.
10. Transcript analysis, regulation of the gene expression and identifying and studying the translation product of a cloned gene (HRT and HART techniques).
11. DNA sequencing methods: Sanger-Coulson method & Maxam- Gilbert method. Automated sequencing.
12. Whole genome analysis- preparation of ordered cosmid libraries, bacteria artificial chromosome libraries. PCR & its application. DNA finger printing (RFLP & RAPD, REP-PCR etc.). Bioinformatics.

Suggested Reading:

1. Old & Primrose. Principals of Gene Manipulation.1994. Blackwell Scientific Publisher
2. Sambrook & Russel. Molecular Cloning. 3 Volumes. 2000. CHSL Press.
3. Genome Analysis. Four volumes 2000 CHS Press.
4. T.A. Brown. Gene Cloning: An Introduction. III ed. Stanley Thrones Publ.

SLS/BOT/E001B . FOREST ECOLOGY

- 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, panned 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 lands.
3. 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
4. Wild Life: Species and distribution, Sanctuaries, Biosphere reserves, wild life and recreation.
5. Forest conservancy and Potential Productivity: Soil, Water relation and nutrition, soil erosion and conservation, potential productivity of forests, site quality evaluation.
6. 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.
 - iii) 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.

7. Environmental Impact Assessment: Maintenance and conservational policies such as Joint Forest Management (JFM) and Agroforestry in the region.

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. GyanodayaPrakashan, 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- 110 030
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.

SLS/BOT/E001C NATURAL RESOURCE MANAGEMENT IN THE HIMALAYA

1. Introduction of Indian and Garhwal Himalaya, Topographic, geomorphic, socio-economic and demographic profile of Uttarakhand.
2. Natural resources and their classification. Utilization, consumption pattern emphasizing with sustainability of natural resource.
3. Natural resource use and management, policy and strategies for appropriate and sustainable natural resource management and its sustainable management and its potential to livelihood security.
4. Status of natural resources and its sustainable management in Garhwal Himalaya. Integrated approaches of natural resource management, natural resource issue and strategies for their management.
5. Concept of environment management, environmental protection and fundamental rights, man & environment.
6. Introduction to environment impact assessment, planning and significance.

7. Disaster management, classification, concept of landslide and earthquake in Garhwal Himalaya.
8. Global warming and climate change, weather & modification, loss of biodiversity. Indicators of climate change and consequences of climate changes. Retreating of glaciers.
9. Impact of climate change on natural resources with special reference to Garhwal Himalaya and strategies for mitigation.
10. Water resources, status and conservation in India.
11. Watershed management techniques (vegetation type conversion, water harvesting, reservoir construction, drainage channelization etc).
12. Water resources in Uttarakhand (glaciers, lakes and rivers of Uttarakhand), utilization pattern; Drainage systems of Ganga, Yamuna and Ramganga.
13. Environment and prospects of hydropower development, Hydro-electric projects and their effects on natural resource management in Uttarakhand. Strategies and policy for water conservation in Uttarakhand.
14. Agroecosystem, farming system, traditional agriculture practices, crop rotation; Land use pattern, land-form, land-use change, soil erosion and productivity, problems and curative measures.
15. Effect of climate change on agro-ecosystem; Conservation of crop diversity in Garhwal Himalaya, challenges of managing agro-biodiversity in Garhwal Himalaya.
16. Traditional seed supply system of mountain farmers, diversity and risks to crop genetic resources, agriculture policy.

SUGGESTED READINGS:

1. Heywood, H.V. 1995. Global Biodiversity Assessment.
2. Lochwood, M., Worboys, G.L. and Ashish, K. 2006. Managing Protected Areas: A Global Guide.
3. Singh, J.S. Singh, S.P. and Gupta, S.R. 2005. Ecology, Environment and Resource Conservation. Anamaya Publ., F-154/2 Ladosarai, New Delhi- 110 030.
anamayapub@vsnl.net.in

SLS/BOT/E001D : PALYNOLOGY AND POLLINATION BIOLOGY

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 exineless pollen grains; pollen expressed and pollen specific genes.
3. **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.
4. **Paynotaxonomy:** Systematic palynology, identification key and evolutionary trends among pollen grains based on palynotaxonomical works.
5. **Aeropalynology 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.
6. **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.

7. **Palaeopalynology:** Introductory idea about palaeopalynological remains, significance of palaeopalynology.
8. **Forensic palynology:** Definition and significance, a few well-known case studies.
9. **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.
10. Breeding systems, self-incompatibility and compatibility control with reference to pollen-pistil interactions and pollen biotechnology.

SUGGESTED READINGS:

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

SLS/BOT/E002A PLANT HEALTH MANAGEMENT

1. Basic procedure in diagnosis of plant diseases: Significance of plant diseases.
2. Seed Pathology: Seed borne fungi. Disease transmitted through seeds. Biodeterioration of seed in storage. Control of seed borne fungi.
3. Nursery disease: Important disease of nursery plants.

Plantation disease: Plantation disease of Chir pine, *Eucalyptus*, Sal, Teak, Shisam, *Populus*, *Acacia* (Catechu).

Important disease of cash crops: Sugarcane, Potato and Ginger. How plants defend themselves against pathogen. Control of crop and forest disease. Treatment of wounds.

Introduction and various forms of Mycorrhiza. Role of Mycorrhiza in Forestry.

Diseases of cereals and Millets.

Diseases of vegetables and fruit trees.

SUGGESTED READINGS:

1. Bilgrami, K.S. 1985. Text Book of Modern Plant Pathology. Bishen Singh Mahendra Pal
2. Singh Dehradun.
3. Butler, E.J. 1973. Fungi and Disease in Plants, Intern, Book Distributers. Dehradun.
4. Singh, R.S.1983. Plants Diseases. Oxford and IBH Publ. Co. New Delhi.
5. Singh, R.S. Principle of Plants Pathology. Oxford and IBH Publ. Co. New Delhi
6. Strobel, G.A. and D.E., Mathre 1970. Outlines of Plant Pathology. Van Nostrand
7. Reinhold Co. New York.
8. Tarr, S.A.J. 1972. The Principle of Plants Pathology. Winchester Press, New York.
9. Western, J.H. 1971. Diseases of Crop Plants. Mc Millan Press London.

SLS/BOT/E002B DIVERSITY AND CULTIVATION OF MUSHROOMS

1. General characteristics and life history: Reproduction, spore print, dissemination, growth size, colour and surface textures, odour, taste, Exudation and fairy rings; Bioluminescence and economic importance.
2. Biodiversity of Mushrooms.
3. Status of Mushroom research in India.
4. Ethnomycological approach of mushrooms, especially in Uttarakhand Himalaya.
5. Edible and poisonous mushrooms. Mushroom recipes, mushroom toxins, disease and pests of mushrooms.
6. Introduction to mushroom groups.
7. Taxonomic study of order Agaricales- Systematics of dark spored families viz., Boletaceae, Bolbitaceae, Boudarzewiaceae, Cortinariaceae, Coprinaceae, Crepidotaceae, Entomataceae, Gomphideaceae, Paxillaceae, Russulaceae; Systematics of light spored families. Agaricaceae, Amanitaceae, Hygrophoraceae, Pluteaceae, Tricholomataceae.
8. Order Aphyllophorales: Introduction and Systematics of Cantharelloid forms, Thelephoroid forms, Cupuloid forms, Clavarioid forms, hydroid forms and poroid forms.
9. Gasteromycetes: Introduction and Systematics of order Hymenogastrales, Lycoperdales, Nidulariales, Phallales, Podaxales and Sclerodermatales.
10. DNA isolation, amplification and ITS; RELP, RAPD Analysis; DNA Primers and markers; PCR machine and working knowledge; Gel Electrophoresis, Use of Geldoc, Sequence and Phylogenetic data analysis.
11. Computer application in Mushroom Science, Formation of clade, dendrograms and sequence alignment; Knowledge to submit mushroom sequence data online, NCBI, MEGA4 and Muttalign.
12. Ecology of mushrooms. Role of mushrooms in forest ecosystem.
13. Mycorrhiza ; endomycorrhiza (arbuscular mycorrhiza), Ectendomycorrhiza (arbutoid mycorrhiza), Ericoid mycorrhiza, Monotropoid mycorrhiza and orchid mycorrhiza.
14. Tissue culture in wild mushrooms.
15. Preparation of compost- paddy straw, saw dust.
16. Cultivation of edible and medicinal mushrooms: *Agaricus*, *Calocybe*, *Flammulina*, *Ganoderma*, *Hericium*, *Lentinus*, *Pleurotus* .

SUGGESTED READINGS:

1. Allen, M.F. 1991. The Ecology of Mycorrhiza. Cambridge Univ. Press, Cambridge.
2. Bakshi, B.K. 1974. Mycorrhiza and its role in forestry, FRI, Dehradun.

3. Chang, S.T. and W.A. Hayes. 1978. *The Biology and Cultivation of Edible Mushrooms*. Academic Press.
4. Hacskaylo, E. 1971. Mycorrhizae, USDA Forest Service Publ. No. 1189. US Govt. Printing Office, Washington, DC.
5. Hawksworth,DL; Sutton, B.C. and Ainsworth G.C. 1983. Dictionary of the Fungi. Kew, Surrey, England.
6. Krieger, LCC. 1967. The Mushroom Handbook. Dover Publications. INC New York.
7. Largent, D.L. 1977. How to identify Mushrooms to genus? I Macroscopic features. Mad River Press. Inc. Eureka.
8. Miller, O.K. Jr. 1981. Mushrooms of North America. EP Dutton, New York.
9. Singer, R. 1986. The Agaricales in Modern Taxonomy. BSMPS, Dehradun.
10. Stamets, P. and J.S. Chitton 1983. The Mushroom Cultivator, Agarikon Press, Olympia, Washington.

SLS/BOT/E002C : APPLIED PLANT ANATOMY

1. Different types of microscopes, their working and utility.
2. Sources of Timber. Importance of knowledge of wood structure.
3. How wood is formed: Cambium and its derivations, secondary growth, juvenile wood and mature wood.
4. Physical features of wood visible on the cross surface of log, sapwood and heart wood, growth rings and growth marks, colour, luster, odour and taste, weight, grain, texture.
5. Gross features of wood visible on longitudinal surface of wood.
6. Ultra structure of wood and techniques: Electron microscope, ultra structure of cell wall, microfibril angle.
7. Natural defects of wood: Reaction wood, Knots, Silica content and other defects due to stress. Defects of timbers to utilization.
8. Wood structure in relation to properties and uses.
9. Criteria and methods of assessment of wood quality in plantation grown timbers, viz: *Eucalyptus* and *Poplar* for pulp and timber.

SUGGESTED READINGS

1. Wilson and Whyte Text Book of Wood Technology. HP Brown, McGraw Hill, New York.
2. Indian Forest Utilization. FRI Vol. I and II. Comparative Wood Anatomy. Sherwin Carlquist.
3. Ramesh Rao, K and Junija. Field Identification of 50 important timbers of India, FRI.
4. Tieman Pitman. Wood Technology. New York.
5. Foster, AS, Nostrand, D Van. Practical Plant Anatomy. New York.
6. Gupta, S. Atlas of Indian Heartwoods- their anatomical features and photomicrographs.
7. Fahh, A. Plant Anatomy. Pergamon Press.

Aerial Photography and Photogrammetry (AP&P):

1. Fundamentals of Aerial Photography, History, Aerial film processing, Procurement, and Security of Aerial photographs, Energy source and atmospheric effects in aerial photography. Principles of Aerial Photos (flight planning).
2. Introduction to Photogrammetry, Geometry of Aerial photos, Stereoscopic photography, Measurement of Height, Aerial Triangulation.
3. Principles and fundamentals of Aerial photo interpretation. Basics of Cartography.

Remote Sensing (RS):

4. Introduction to Remote Sensing. The electromagnetic spectrum, Energy interaction with atmosphere and earth surface, satellite and sensors, Remote sensing data acquisition.
5. Principles and basic concepts of Multi spectral, Thermal and hyperspectral Scanning: Across-track and Along Track multispectral Scanning. History of Space Imaging
6. Image Interpretation: Type of Imagery, elements of Interpretation, Techniques of Visual Interpretation, Role of remote sensing in ecological research.

Digital Image Processing (DIP):

7. Fundamentals of digital image processing, Image rectification, Restoration and Enhancement.
8. Image classification: Supervised classification, unsupervised classification, Hybrid classification, Post-classification smoothing and Classification accuracy assessment.
9. Principles of microwave sensing, Geometric characteristics, Spatial resolution. Spaceborne Radar System, Application of passive microwave sensing.

Geoinformatics (GIS):

10. Basics of Computer, Hardware and software,
11. Principles and basics of Geographic Information System: Raster and Vector GIS, Database creation and management. Network Analysis, Spatial data integration and Modelling.
12. Basics of Global Positioning System, GPS Satellites and GPS utility.

Suggested Readings:

1. Lillesand & Kieffer, Remote Sensing and Image Interpretation. John Wiley & Sons, New York.

2. Sabins, F.F., Jr. Remote Sensing: Principles and interpretation.
3. Bhatia, S.C. Fundamentals of Remote Sensing.
4. Chanda, Datta, Majumdar. Digital Image Processing & Analysis.
5. Chang, K.T. Introduction to Geographic Information Systems.
6. Rao, et al., Geographic Information System.
7. Johnston C.A. Geographic Information Systems in ecology.
8. Ahmed, E. I & Rabbany. Introduction to Global Positioning System.
9. Aronoff, S. 1991. Geographic Information Systems: A Management Perspective. Ottawa WDL Publ.
10. Barrett, E.C. 1982. Introduction of Environmental Remote Sensing. Chapman and Hall.
11. Burrough, P.A. 1986. Principle of Geographic Information System for Land Resources Assessment. Oxford University Press.
12. Colwell, R.N. 1983. Manual of Remote Sensing. Vol. I,II American Society of Photogrammetry.
13. Curran, P.J. 1985. Principle of Remote Sensing. Longman Group.
14. Dury, S.A. 1990. A Guide to Sensing. Interpreting Image of Earth. Wiley and Sons.
15. Hord, R.M. 1986. Remote Sensing: Method and Application, John Wiley and Sons.
16. Jenson, J.R. 1996 Introductory Digital Image Processing, Prentice Hall. New Delhi.
17. Johnson, P.I. 1969. Remote Sensing in Ecology. Univ. Georgia Press, Athens.
18. Rampal, K.K. 1982. Text Book of Photogrammetry. Oxford and IBH Press.,
19. Rees, W.G. 1990. Physical Principles of Remote Sensing, Cambridge University Press.
20. Schander, E. 1976, Remote Sensing for Environmental Sciences. Springer Verlag.
21. Ulaby, F.T. Moor, R.K. and Fung, A.K. 1982. Microwave Remote Sensing Active and Passive. Vol. I and II Wesley Pub.

SLS/BOT/E03 LABORATORY COURSE II
(Based on elective papers)

SLS/BOT/E001A

1. Isolation of DNA and plasmid.
2. Restriction digestion of vector and DNA.
3. Ligation of DNA construct and vector.
4. Demonstration of transformation and selection of recombinant clones.

SLS/BOT/E001B

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.

SLS/BOT/E001C

1. Field surveys to study various types of natural resources in Uttarakhand Himalaya.
2. Study on the pressures impinging on the natural resources.
3. Observations on the Environment Impact Assessment of Hydroelectric Power Project in Uttarakhand Himalaya.
3. Observations on Natural disasters viz., floods, landslides, forest fires frequent in Himalayas
4. Visits to National Parks, Wild life Sanctuaries and Biosphere Reserves.

SLS/BOT/E001D

1. Pollen morphological studies of some pterodophytes, 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.

SLS/BOT/E002A

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.

SLS/BOT/E002B

1. Collection, preservation and identification of wild mushrooms
 2. Morphological features: field notes, chemical spot tests, photography, sporeprint, colour change, smell, taste, etc.
 3. Anatomical features: Microscopic studies, Mycorrhizal studies.
 4. Ecological Observation.
 5. Tissue culture techniques: Media preparation, solid and liquid culture media preparation. Pure culture techniques. Sub culturing, Lyophilization, Maintenance of mushroom culture.
 6. Cultivation of *Agaricus*, *Calocybe*, *Flammulilna*, *Ganoderma*, *Lentinus* and *Volvariella*.
1. DNA Isolation, amplification and ITS, RELP, RAPD analysis, DNA primers and markers. PCR and Gel electrophoresis.

SLS/BOT/E002C

1. Different types of Microscopes, their working and utility. Research, Polarized and Electron Microscopes.
2. Juvenile wood and mature wood: Maceration techniques.
3. Section cutting and mounting of different types soft and hard woods (locally available). Microscopic and anatomical features of wood viz: bamboo, canes and coconut.
4. Ultra structure of the wood and techniques. Study of cell wall, microfibril angle and proportion of tissues.
5. All physical features visible on cross surface of log.
6. Gross features of wood visible on longitudinal surface.

SLS/BOT/E002D

2. Stereo test and study of different types of aerial photos, Orientation of Stereomodel for interpretation and mapping.
3. Determination of Scale, Determination of Height and Slope.
4. Visual interpretation of aerial photos and satellite data on different scales, Study of different types of satellite data products.
5. Study of Multispectral data, Study of Image Processing Systems, Display of raw data, Histogram analysis.
6. Digital classification and Enhancement of satellite data, Information extraction using DIP techniques.
7. Study of Geographic Information System, Geo-referencing, designing GIS database, Editing spatial and attribute data, out put presentation.

SEMESTER IV

SLS/BOT/C016 CONSERVATIONAL BIOLOGY

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.
5. Threats to biodiversity: Habitat loss and fragmentation, Genetic drift, Inbreeding, Disturbance, Pollution, Climate Change, Overexploitation, Invasive Species, Disease,
6. Global environmental problems: Global warming, ozone depletion, desertification.
7. Extinction to species: Susceptibility to extinction causes of species extinction, endangered species, Red and Green Data Books.
8. 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.
9. Conservation of Biological diversity: Genetic principles in conservation, biodiversity assessment and inventory.
10. 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.
11. Conservation of energy resources; conservation and maintenance of non renewable fossil fuel resources; Conservation of biodiversity based renewable energy resources.
12. Conservation of biological resources: In situ and Ex Situ Conservation Strategies, Designing Networks of Protected Areas; Restoration of endangered species, Problems of Small Populations, Establishing New Populations; Sustainable use and public participation, Guidelines for Successful Monitoring, politics and economics in the decision-making process, Challenges for the future.
13. Protected Area Network, PAN with special reference to Uttarakhand and India. 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.
14. Ecosystem restoration, Strategies and plans for restoration, Passive restoration (natural recovery) and active restoration.
15. National Forest Policy 1929, Wildlife (Protection) act 1975, Forest (Conservation) Act 1980, Environment (Protection) Act 1986, Fisheries Act 1987, 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: Principals 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 Edinberg Building, Cambridge CB2ZRU, 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.

SLS/BOT/C017 BIOTECHNOLOGY AND GENETIC ENGINEERING OF PLANTS AND MICROBES

1. Biotechnology: Basic concepts, principles and scope.
2. Plant cell and tissue culture: General introduction, history, scope, concept of cellular differentiation, totipotency.
3. Organogenesis and adventive embryogenesis: Fundamental aspects of morphogenesis, somatic embryogenesis and androgenesis, mechanisms, techniques and utility.
4. Somatic hybridization: Protoplast isolation, fusion and culture, hybrid selection and regeneration, possibilities, achievements and limitations of protoplast research.
5. Applications of plant tissue culture: clonal propagation, artificial seed, production of hybrids and somaclones, production of secondary metabolites/natural products, cryopreservation and germplasm preservation.
6. Recombinant DNA technology: Gene cloning principles and techniques, construction of genomic and cDNA libraries, choice of vectors, DNA synthesis and sequencing, polymerase chain reaction, DNA finger printing.
7. Genetic engineering of plants: Aims, strategies for development of transgenics (with suitable examples), *Agrobacterium*- the natural genetic engineer, T-DNA and transposon mediated gene-tagging, chloroplast transformation and its utility, intellectual property rights, possible ecological risks and ethical concerns.
8. Microbial genetic manipulation: Bacterial transformation, selection of recombinants and transformants, genetic improvement of industrial microbes and nitrogen fixers, fermentation technology.
9. Genomics and proteomics: Genetic and physical mapping of genes, molecular markers for introgression of useful traits, artificial chromosomes, high throughput sequencing, genome projects, bioinformatics, functional genomics, microarrays, protein profiling and its significance.

SUGGESTED READINGS:

- Bhojwani, S.S. and Razdan, M.K. 1996. Plant Tissue Culture: Theory and Practice (a revised edition). Elsevier Science Publishers, New York, USA.

- Bhojwani, S.S. 1990. Plant Tissue Culture: Applications and Limitations. Elsevier Science Publishers, New York, USA.
- Brown, T.A. 1999. Genomes. John Wiley & Sons (Asia) Pvt. Ltd., Singapore.
- Callow, J.A., Ford-Lloyd, B.V. and Newbury, H.J. 1997. Biotechnology and Plant Genetic Resources: Conservation and Use. Cab International, Oxon, UK.
- Chrispeels, M.J. and Sadava, D.E. 1994. Plants, Genes and Agriculture. Jones & Bartlett Publishers, Boston, USA.
- Collins, H.A. and Edwards, S. 1998. Plant Cell Culture. Bioscientific Publishers, Oxford, UK.
- Glazer, A.N. and Nikaido, H. 1995. Microbial Biotechnology. W.H. Freeman & Company, New York USA.
- Gustafson, J.P. 2000. Genomes. Kluwer Academic Plenum Publishers, New York, USA.
- Henry, R.J. 1997. Practical Applications of Plant Molecular biology. Chapman & Hall, London, UK.
- Jain, S.M., Sopory, S.K. and Veilleux, R.E. 1996. In Vitro Haploid Production in Higher Plants, Vols, 1-5., Fundamental Aspects and Methods. Kluwer Academic Publishers, Dordrecht, The Netherland.
- Jolles, O. and Jornvall, H. (Eds). 2000. Proteomics in Function Genomics. Birkhauser Verlag, Basel, Switzerland.
- Kartha, K.K. 1985. Cryopreservation of Plant cells and Organs. CRC Press, Boca Raton, Florida, USA.
- Old, R.W. and Primrose, S.B. 1989. Principles of Gene Manipulation. Blackwell Scientific Publications, Oxford, UK.
- Primrose, S.B. 1995. Principles of Genome Analysis. Blackwell Science Ltd., Oxford, UK.
- Raghavan, V. 1997. Molecular Biology of Flowering Plants. Cambridge University Press, New York, USA.
- Shantharam, S. and Montgomery, J.F. 1999. Biotechnology, Biosafety & Biodiversity. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi.
- Vasil, I.K. and Thorpe, T.A. 1994, Plant Cell and Tissue Culture. Kluwer Academic Publishers, The Netherlands.

SLS/BOT/C018 LABORATORY COURSE I

A. Laboratory/Field Exercises in Conservation Biology.

1. To study the pattern of regional biodiversity.
2. To study the Hot spots and key stone species.
3. Survey of biological resources.
4. Study of habitat loss with respect to plant species. To observe factors expediting habitat loss viz., floods, forest fires, land slides, natural and anthropological activities.
5. Visits to national parks, sanctuaries and biosphere reserves of Uttarakhand.
6. Visit to ecosystem restoration sites in mined areas in Uttarakhand Himalayas.

B. Laboratory/Field Exercises in Biotechnology and Genetic Engineering.

1. Growth characteristics of *E. coli* using plating and turbidimetric methods.
2. Isolation of plasmid of *E. coli* by alkaline lysis method and its quantitation spectrophotometrically.
3. Restriction digestion of plasmid and estimation of the size of different DNA fragments.

4. Cloning of a DNA fragment in a plasmid vector, transformation of the given bacterial population and selection of recombinants.
5. Demonstration of DNA sequencing by Sanger's dideoxy method.
6. Demonstration of protoplast fusion employing PEG.
7. Organogenesis and somatic embryogenesis using appropriate explants and preparation of artificial seed.
8. Co-cultivation of the plant material (e.g. leaf discs) with *Agro bacterium* and study GUS activity histo-chemically.

Manuals for Laboratory Exercises

1. Butenko, R.G. 2000. Plant Cell Culture. University Press of Pacific.
2. Collin, H.A. and Edwards, S. 1998. Plant Cell Culture. Bioscientific Publishers, Oxford, UK.
3. Dixon, R.A. (Ed.) 1987. Plant Cell Culture: A Practical Approach. IRL Press, Oxford.
4. Gelvin, S.B. and Schilperoort, R.A. (Eds.), 1994. Plant Molecular Biology Manual, 2nd edition, Kluwer Academic Publishers, Dordrecht, The Netherlands.
5. George, E.F. 1993. Plant Propagation by Tissue Culture. Part 1. The Technology, 2nd edition, Exegetics Ltd., Edington, UK.
6. George, E.F. 1993. Plant Propagation by Tissue Culture. Part 2. In Practice, 2nd edition, Exegetics Ltd., Edington, UK.
7. Glick, B.R. and Thompson, J.E. 1993. Methods in Plant Molecular Biology and Biotechnology. CRC Press, Boca Raton, Florida.
8. Glover, D.M. and Hames, B.D. (Eds), 1995. DNA Cloning 1: A Practical Approach; Core Techniques, 2nd edition, PAS, IRL Press at Oxford University Press, Oxford.
9. Hackett, P.B., Fuchs, J.A. and Messing, J.W. 1988. An Introduction to Recombinant DNA Techniques: Basic Experiments in Gene Manipulation. The Benjamin/ Cummings Publishing Co., Inc Menlo Park, California.
10. Hall, R.D. (Ed.), 1999. Plant Cell Culture Protocols. Humana Press, Inc., New Jersey, USA.
11. Shaw, C.H. (Ed.) 1988. Plant Molecular Biology: A Practical Approach. IRL Press, Oxford.
12. Smith, R.H. 2000. Plant Tissue Culture: Techniques and Experiments. Academic Press, New York.

SLS/BOT/E004 Dissertation/ Project Work

Dissertation is an elective and optional for students scoring 75% or more upto second semester. The dissertation is to be allotted in the beginning of III Semester and would be submitted at the time of the examination of IV Semester. The distribution of marks for the Dissertation will be as below:

Periodical presentation	: 60 Marks
Dissertation	: 180 Marks
Viva-Voce	: 60 Marks
Total	: 300 Marks

The Dissertation would carry 09 credits in all.

The dissertation/ Project report shall be evaluated jointly by the supervisor and one external examiner.

Following topics/research fields are proposed to undertake Dissertation/ Project Work.

Any other current trends / topics suggested by the Departmental committee may also be considered for the dissertation/project work.

Anatomy of Himalayan woods

Chromosome Analysis and Indexing of Himalayan Flora

Conservation of Endangered Species

Environment Impact Assessment

High Altitude Ecology and Climate Change

Invasion Ecology

Inventorization of unexplored Areas and Hotspots

Limnology

Plant Biodiversity Assessment

Pollution Monitoring

Population/weed/ Reproductive Biology

Survey of Less known Economic Plants

Or

In lieu of dissertation any two of the following elective papers of 03 credits each and one lab course of 03 credits (total 09 credits) would be chosen by the student.

SLS/BOT/E005A : PROPAGATION TECHNIQUES

1. Environmental factors of Propagation: Fundamental microclimate and edaphic factors in the propagation environment; Managing the propagation environment; Management of edaphic factors in propagation; Management of Biotic factors-Pathogen and Pest Management; Post propagation care
2. Seed Propagation: Sources of seed, Harvesting and processing seeds, Seed testing and seed storage; Dormancy and regulation of germination; Field nurseries for transplant production
3. Vegetative Propagation: Selection and management of clones in vegetative propagation; Reasons for using clonal cultivars; Genetic basis of clones; Non-genetic variation within clones; Propagation sources of their management
4. Propagation by Cuttings: Observations of Adventitious root and bud formation; Factors affecting regeneration of plants from cuttings; Biochemical basis for Adventitious root formation; Importance and advantages of propagation by cuttings; Types of cutting, stock plants, rooting media; Management practices- Cutting nutrition, care of cuttings; Handling field propagated plants and container grown plants.
5. Propagation by Grafting: Reasons for grafting and budding, Natural grafting; Polarity and genetic limits of grafting, Graft incompatibility; Types of grafts: Detached scion graftage, Approach graftage, Repair graftage; Scion-rootstock relationship; Aftercare of grafted plants.
6. Techniques of Budding: Rootstock for budding; Time of budding; Types of budding; Micro budding.
7. Layering and its natural modifications: Physiology of regeneration by layering; Procedures in Layering; Management of plants during layering; Plant modifications resulting in natural layering;
8. Micro-propagation: Micro-propagation of plantlets from tissue culture; Types of systems used to regenerate plantlets by micro-propagation Callus, cell and protoplast culture systems.

Practical course:

1. Seed testing of different species for variability
2. Working out the germination percentage of different types of seeds.
3. To study Plant propagation by seed (scarification, stratification)
3. Effect of pretreatments on germination of seeds.
4. Propagating different plants by using budding and layering in the field at some horticultural station,
5. Plant propagation by cutting and layering techniques.
6. Propagation through specialized vegetative structures and micro propagation.
7. Preparation of different types of tissue culture media.
8. Development of callus from different explants.
9. Regeneration of plants from callus.
10. Micropropagation of plants using different explants.
11. Developing somatic embryos.
12. Development of synthetic seeds.

SUGGESTED READINGS:

1. Bajaj YPS. (ed). 1988. *Biotechnology in Agriculture and Forestry*. Springer-Verlag.
2. Gupta P.K. 2000. *Elements of Biotechnology*. Rastogi Pub.
3. Kumar S. and Singh M.P. 2008. *Plant Tissue Culture*. APH Pub.
4. Mandal A.K and Gibson G.L. (ed.). 1997. *Forest Genetics and Tree Breeding*. CBS.
5. Hong, T. D. and Ellis, R. H. 1996. *A protocol to determine seed storage behaviour*. IPGRI Technical Bulletin No. 1. (J. M. M. Engels and J. Toll, vol. Eds.) International
6. Khullar, P. *et al.* 1992. *Forest seed*. ICFRE, New Forest, Dehra Dun.
7. Leadem, C.L. 1984. *Quick Tests for Tree Seed Viability*. B.C. Ministry of Forests and Lands, Canada.
8. Schmidt, L. 2000. *Guide to handling of tropical and subtropical forest seed*. DANIDA Forest Seed Centre, Denmark.
9. ISTA. 1993. *International Rules for Seed Testing*. International Seed Testing Association, Zurich, Switzerland.
10. Hartman, H.J. *et al.*, 1990 : Plant propagation . Principles and practices. Prentice Hall, New Delhi.
11. Schwalz. M. 1975. Guide to commercial hydroponics. Israel University, Jerusalem.
12. Sharma, V.K. 1996. Plant Nurseries: Techniques, production and management. Indian Pub. New Delhi.
13. Sadhu, M.K. 1989 : Plant propagation. New Age Pub. New Delhi.
14. S. S. Bhojwani and M. K. Razdan. 1996. Plant tissue culture: Theory and Practice. Elsevier Publishers, Amsterdam.
15. Dixon R. A. and Gonzales R. A. (Ed.) 1994. Plant cell culture, a practical approach. Second Edition. Oxford University Press, Oxford.
16. Gamborg O. L. and G. C. Phillips. 1995. Plant cell, tissue and organ culture, fundamental methods. Springer International student Edition.
17. Sharma, R.R. and Manish Srivastava. Plant Propagation and Nursery Management (Hardcover).
18. Aldriance GW and Brison FR (2000) Propagation of horticultural plants. Mc Grow Hill Book Company. Inc, New York.
19. Bose T. K., Mitra S.K., Sadhu M.K. and Das P. (1997) Propagation of Tropical and Sub tropical Horticultural Crops. IInd Edition, Naya Prakash, Calcutta.
20. Sharma RR (2002) Propagation of Horticultural crops: Principles and Practices. Kalyani Publishers, New Delhi.

SLS/BOT/E005B .ENVIRONMENT MANAGEMENT WITH REFERENCE TO WESTERN HIMALAYA.

1. Introduction to the Environmental Management, Major Environmental Problems, Environmental ethics; Resource and conflicts, Environmental Laws; Stockholm Conference, The Earth summit, The Copenhagen Conference, Environmental Protection and Fundamental rights, Environmental Governance in India, Man and Environment, Trade and Environment; the WTO and GATS, Environment Concerns and WTO.
2. Introduction to the Environmental Impact Assessment; Planning and Significance, EIA practices and future trends in India; Legal frame work for EIA. Impact of forest fires, Forest Fire

Assessment and Risk Zonation. Thermal power stations, Power line and roads, River valley projects, Urbanization and Industrialization, Mining activities, GHGs, CFCs, fossil fuels etc., Flood monitoring, Snow melt and Glaciers, Ozone Layer Depletion. Principles of Environmental Analysis, Role of remote sensing in EIA.

3. Environmental Management and Natural Resources, Air Pollution, Water Pollution and its Management, Environmental Pollution Act; Waste disposal and management, Integrated solid waste management, Recycling, Incineration, Sanitary landfill, Sewage disposal and sewage treatment; Hazardous wastes.
4. Environmental policy and environmental management system, Audit items and audit procedures, ISO Certification.
5. Watershed management: Definition and basic concepts, Aims and Principles, Importance of integrated watershed management, Principal watershed problems of India.
6. Basic concept of ecosystem and community, Biological populations and communities, Ecological niches, interaction among species, Key stone species, Species diversity and edge effects, Major terrestrial and aquatic biomes, Energy Flow, Food webs and trophic levels, Ecosystem diversity, Climate shifts, Species movements.
7. Biodiversity and conservation, *In-situ* and *ex-situ* conservation, Indigenous knowledge and biodiversity conservation, Loss of biodiversity- causes and its impact; Convention on biodiversity, Major Biodiversity resources. Global trends of invasive species, threats and managing invasive plants.
8. Protected areas concept and purpose, type of protected areas and threats, In situ conservation and protected areas; Role of local communities in protected area management.
9. Renewable Energy Production and Management: Energy concepts, present global energy use, future energy needs, renewable needs, energy conservation.
10. Biofuel plants- *Jatropha*, sugarcane and oil crops, Biofuel plantation, energy criteria for species selection, achievement of sustainable Biofuel production; Bioconversion, utilization of biomass sources, Incineration of organic wastes for energy. Alien invasive species and bioenergy production; Bioenergy and food production controversies. Carbon sequestration and carbon pools.

Practical:

1. Identification of Key stone species.
2. To study phytoplankton and benthos in aquatic bodies.
3. Analysis of water for dissolved oxygen.
4. Estimation of biological oxygen demand and chemical oxygen demand.

5. Case study of any hydroelectric power project in Uttarakhand with EIA prospective using remote sensing and GIS.

SUGGESTED READINGS

1. FAO Conservation Guide Nos. 12, 13/1, 13/3, 13/4, 13/6, 14. Rome.
2. Heywood, H.V. 1995. Global Biodiversity Assessment.
3. Lochwood, M., Worboys, G.L. and Ashish, K. 2006. Managing Protected Areas: A Global Guide.
4. Ramakrishnan, P.S., Saxena, K.G. and Chandrashekara, U.M. 1998. Conserving the sacred for Biodiversity Management. Oxford and IBH Publ. Co. New Delhi
5. Richard, P.P. 1998. Essentials of Conservation Biology. Boston University.

SLS/BOT/E005C BIOINFORMATICS AND BIOLOGICAL DATA BASE

1. Concepts, overview and scope of bioinformatics, Bioinformatics and the Internet, Basic principles of computing in bioinformatics, Use of databases in Biology: primary databases: Gene Bank, SWISSPROT, PDB; specialized databases: PFAM, SCOP, PROSITE; database querying using keywords and search engines.
2. Annotated sequence databases, Genome and organism-specific databases, miscellaneous databases, Sequencing DNA, RNA and proteins, determination of protein structure, Gene and protein extraction data.
3. Data retrieval with Entrez, DBGET/Link DB and SRS (sequence retrieval system), Sequences similarity searches, Amino acid substitution matrices, databases searches with FASTA and BLAST, Multiple sequences alignment and family relationships, Protein families and pattern databases.
4. Principles of genome annotation, Annotation tools and resources, Conceptual models of protein structure, protein structure and function, Obtaining, viewing and analysing structural data, Classification of proteins of known three-dimensional structure: CATH and SCOP, Protein structure prediction, Secondary structure prediction.
5. Microarray data analysis, tools and resources, Sequences sampling and SAGE, Analysing data from 2D-PAGE gels, Analysing protein mass spectrometry data, modeling and restructuring molecular pathways, Protein interaction informatics, Higher-order models.
6. Phylogenetics, cladistics and ontology; Building phylogenetic trees; Evolution of macromolecular sequences.
7. Chemoinformatic resources, Conventions in representing molecules, Pharmainformatics.

SUGGESTED READINGS

1. Attwood, T.K. & Parry-Smith, D.J. 1999. Introduction to Bioinformatics. Addison Wesley Longman, Harlow, Essex.
2. Baxevanis, Andreas D. & Quellerie, B.F. Francis 2004. Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins, 3rd edition. Wiley Blackwell.
3. Brown, T.A. 2006. Genomes 3. Garland Science.

4. Lesk, A.M. 2005. Introduction to Bioinformatics, 3rd edition. Oxford University Press, Oxford.
5. Mount, D.W. 2004. Bioinformatics: Sequence and Genome Analysis. Cold Spring Harbor Laboratory Press, U.S.
6. Parish, J.W. & Twyman, R.M. 2002. Instant Notes in Bioinformatics. Taylor & Francis.
7. Patthy, L. 1999. Protein Evolution. Blackwell Science Ltd., Oxford.
8. Primrose, S.B. & Twyman, R. Principles of Genome Analysis and Genomics. Blackwell, Oxford.
9. Zyelibil, M & Baum, J.O. 2007. Understanding Bioinformatics. Garland Science.

Database Sites

www.ncbi.nlm.nih.gov

www.dnalc.org

www.hugo-international.org

www.ensembl.org

Practical course

1. Introduction to bioinformatics softwares and their downloading and installation.
2. Hands on experience on the database BLAST, FASTA.
3. Searching sequences, data analysis and modeling molecular pathways.
4. Constructing Phylogenetic trees.

SLS/BOT/E005D : SEED PATHOLOGY

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.
4. Nature of seed infection. Systemic infection through flower, fruit and seed stock. Penetration through seed coat, natural openings and inflicted openings.
5. Longevity of seed borne pathogens. Factors influencing longevity.
6. Epiphytology of seed borne diseases, monocyclic and polycyclic diseases
7. 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.
8. Study of seed borne diseases of certain specific crops, cereals, millets, pulses, oil crops, fibre crops, and vegetable and timber crops
9. Control of seed borne pathogens: selection of seed production areas, crop management, seed treatment, certification, plant quarantine and disease resistance.

Practical:

1. Field inspection of seed crops and visual examination of seeds for infections.
2. Seed soaking for the detection of certain seed borne pathogens (fungi) and nematodes.
3. Seed washing tests and incubation methods.
4. Seedlings symptomatology tests.
5. Detection of bacteria by Agar Plate methods.

6. Viruses : Physical examination, Grow out tests, Enzyme linked immunoabsorbent assay (ELISA) and Polymerase Chain Reaction (PCR).
7. Visit to seed processing plants and seed testing laboratory.
8. Reduction of seed inoculum by chemical seed treatments.
9. Testing amount of pesticides in treated seeds.

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. Sindair. CRC Press. II Edition.
5. Desai, B.B. Seed Handbook. CRC Press.
6. Singh, Gurnam, Seed Pathology. Pointer Publisher, Jaipur.
7. Sing, 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

SLS/BOT/E006 LABORATORY COURSE II

Students will have to choose two practical courses from the theory papers opted by the student. Syllabus of each practical course has been mentioned at the end of theory paper.