SYLLABUS

HNB GARHWAL UNIVERSITY, SRINAGAR-GARHWAL
2011-2012 ONWARDS
Department of Botany and Microbiology
Master of Science
1. BOTANY
(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 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 mandatory for every student. The dissertation is to be allotted in the beginning of III Semester and would be submitted during the examination of the IV Semester.

M. Sc. Semester I (July to November)

Code	Paper	Credits*
BSC101	I. Mycology and Microbiology	03
BSC102	II. Phycology and Bryology	03
BSC103	III. Pteridology, Gymnosperm and Palaeobotany	03
BSC104	IV. Taxonomy and Diversity of Flowering Plants	03
BSC105	V. Laboratory Course I**	03
BSC106	VI. Laboratory Course II	03

Core Credits= 18

M. Sc. Semester II (December to April)

Code	Paper	Credits
BSC107	VII. Plant Development and Reproductive Biology	03
BSC108	VIII. Resource Utilization, IPR and Ethnobotany	03
BSC109	IX. Cytogenetics and Molecular Biology	03
BSC110	X. Plant Breeding and Biostatistics	03
BSC111	XI. Laboratory Course I	03
BSC112	XII. Laboratory Course II	03

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

M. Sc. Semester III (July to November)

Code	Paper	Credit
BSC113	XIII. Plant Physiology and Biochemistry	03
BSC114	XIV. Ecology and Remote Sensing	03
BSE115	XVa. Recombinant DNA Technology XVb. Ecosystem Analysis, GIS and Remote Sensing XVc. Forest Ecology XVd. Natural Resource Management in Himalaya XVe. Palynology and Pollination Biology XVf. Propagation Techniques Any other Elective course offered by other Department	03 each
BSE116	XVIa. Plant Health Management XVIb. Diversity and Cultivation of Mushrooms XVIc. Environmental Management and Basics of Nanotechnolo XVId. Bioinformatics and Biological Database XVIe. Seed Pathology XVIf. Applied Plant Anatomy Any other elective course offered by other Department	03 each
BSC117	XVII. Laboratory Course I	03
BSE118	XVIII. Laboratory Course II	03

Core Credits 09 + Elective Credits 09; Total Credits= 18 + 03 credits of self study.

M. Sc. Semester IV (December to April)

Code	Paper	Credit
BSC119	XIX. Conservation Biology	03
BSC120	XX. Biotechnology and Genetic Engineering	03
BSC121	XXI. Laboratory Course I	03
BSE122	XXII. Dissertation	09

Core Credits 09 + Elective Credits 09; Total Credits= 18 + 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 semesters of Self Study (Seminars).

* 01 Credit= 01 hour of lecture/instructions per week; 01 Credit course= 15 hours of lectures per semester.
** 03hours of laboratory course shall be considered equivalent to 01 hour of lecture.

Dissertation/ Project Work
Anatomy of Himalayan woods
Chromosome Analysis and Indexing of Himalayan Flora
Conservation of endangered species
Ecosystem analysis.
Environmental 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

BSC 101. 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. Mycotoxins.
5. Phytopathogenic fungi.

MICROBIOLOGY

6. A brief history of Microbiology, the diversity of micro-organisms, microbial growth, microbial control.
7. Archaebacteria and Eubacteria: General account; ultrastructure, nutrition and reproduction; biology and economic importance; cyanobacteria- classification, salient features and economic importance.
8. Viruses: Characteristics; isolation and purification of viruses; chemical nature, replication, Transmission of viruses; economic importance.
9. Phytoplasma: General characteristics and role in causing plant diseases. (e.g. sandal spike disease, sesamum phyllody, little leaf of brinjal)
10. Immunology: Structure of antigens and antibodies, antigen- antibody reaction, , Mechanism of antigen-antibody reactions. Vaccines and toxoids, Hypersensitivity
11. Industrial Microbiology: fermentation, alcoholic beverages, dairy products (cheese and butter), enzymes (amylase, protease), industrial spoilage of food and dairy products, Preparation of papers, textiles, cordage, leather, paints and rubber, Biofertilizers and biopesticides.
12. Environmental microbiology, soil and water.

SUGGESTED READINGS:

1. Ainsworth, G.C. 1971. Ainsworth and Bisby's Dictionary of Genera of Fungi. Central Myco. Inst. Kew, Surrey.UK.
2. Alexopoulus, C.J., Mims, C.W. and Blackwell, M. 1996. Introductory Mycology. John Willey & 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. Mc Graw Hill, New York.
10. Ross, F.C. 1983. Introductory Microbiology. Charles E. Merril. 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. Acadmic 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. Daginawala 1996. General Microbiology 2 Vols. Himalaya Pub. House, New Delhi.
23. Ross, F.C. 1983. Introductory Microbiology. Charles E. Merril Publ. Co. Columbus. Ohio.

BSC 102. Paper II: PHYCOLOGY AND BRYLOGY

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 Protochlorophyta, 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.

BRYOPHYTES

8. Morphology, structure reproduction and life history.
9. Classification and Phylogeny of various groups.
10. General account of Sphaerocarpales, Marchantiales, Jungermanniales, Calobryales, and Anthocerotales.
11. Sphagnales, Andreales, Funariales, Buxbauniales and Polytrichales.
12. . Ecology of bryophytes with special reference to Himalaya, their association with other organism.
13. Fossil bryophytes, physiology and morphogenesis.

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.

BSC 103. Paper III: PTERIDOLOGY, GYMNOSPERMS AND PALAEOBOTANY

PTERIDOPHYTA

1. History, origin, classification, present and past distribution, morphology and life history of the following types.

   a. Psilopsida: Psilophytales (*Psilophyton*) and Psilotales (*Psilotum*).

   b. Lycopsida: Protoleopidodendrales *(Protolepidodendron*), Lepidodendrales (*Lepidodendron*), Lycopodiales (*Phylloglossum*), Lepidospermales (*Lepidocarpon*) and Isoetales (*Isoetes*).

   c. Sphenopsida: Hyeniales (*Hyenia*), Sphenophyllales (*Sphenophyllum*) and Calamitales (*Calamites).*

   d. Pteropsida: Coenopteridales – A general account, Ophioglossales (*Ophioglossum)* Marattiales (*Marattia*), Osmundales (*Osmunda*), Filicales (*Cyathea*), Marsileales (*Regnellidium*), Salviniales (*Azolla*) and Indian fossils.

2. General topics: Origin and evolution of Pteridophytes, Heterospory and seed habit.

GYMNOSPERMS

3. 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.
   a. Pteridospermales: Palaeozoic and Mesozoic groups with references to Lyginopteridaceae (*Lyginopteris*) and Medullosaceae (*Trigonocarpus*), A general account of Glossopteridaceae.
   b. Bennettitales: Cycadeoidaceae, Williamsoniaceae and Wielandiellaceae.
   c. Cycadales: A detailed account including distribution of living Cycads.
   d. A general account of Pentoxylales and Cordaitales.
   e. Ginkgoales: *Ginkgo.*
   f. A general account of fossil and living Coniferales and Taxales.
   g. Ephedrales, Welwitschiales and Gnetales: A general account.
4. Evolutionary tendencies in Gymnosperms.
5. Economic importance of Gymnosperms.

PALAEOBOTANY

6. Definition of fossil, different types of plant fossil as per their mode of preservation, concept of form genus.
7. Indian Gondwana Sequence. Classification, distribution, Mega flora succession through Sequence.
8. Introductory idea of Continental Drift Hypothesis.

SUGGESTED READINGS:

1. Andrews, HN. 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.

BSC 104. 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: anatomy, palynology, embryology, phytochemistry,
5. Taxonomic tools: histological, cytological, phytochemical, serological, biochemical and molecular techniques.
6. 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.

7. Herbarium and Botanical gardens: General account.
8. Plant exploration in India with reference to North west and Uttarakhand Himalaya
   Status of flowering plant diversity in Garhwal Himalaya.

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

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 Heyhood, 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 Educationnal Books Ltd., London.
9. Heywood, V.H. and Moore, D.M. 1984. Current Concepts in Plant Taxonomy. Academic Press, London
10. Hutchinson, J. 1973. The Families of Flowering Plants. 2 Vols. Oxford University Press, Oxford.
11. Jain, S.K. and Rao, R.R. 1977. A handbook of Field and Herbarium methods. Today and Tomorrow, New Delhi.
12. Jones, A.D. and Wilbins, A.D. 1971. Variations and Adaptations in Plant Species. Hieman & Co. Educational Books Ltd., London.
13. Jones, S.B., Jr. and Luchsinger, A.E. 1986. Plant Systematic (2nd edition). McGraw-Hill Book Co., New York.
14. Lawrence, H.W. 1951. Taxonomy of Vascular Plants. Reprint Oxford and IBH, New Delhi.
15. Naithani, B.D. 1985. Flora of Chamoli. 2 Vols, BSI, Calcutta.Nordenstam, B., El Gazaly, G. and Kassas, M. 2000. Plant Systematic for 21st Century. Portlant Press Ltd., London.
16. Radford, A.E. 1986. Fundamentals of Plant Systematics. Harper & Row Publications, USA.
17. Singh, H. 1978. Embryology of Gymnosperms. Encyclopaedia of Plant Anatomy X. Gebruder 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.

BSC105 PaperV LABORATORY COURSE I

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

2. Symptomatology of some diseased specimens: White rust, downy mildew, powdery mildew, rusts, smuts, ergot, groundnut leaf spot, red rot of sugarcane, wilts, paddy blast, citrus canker, bacterial blight of paddy, angular leaf spot of cotton, tobacco mosaic, little leaf of brinjal, sesame phyllody, mango malformation.

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

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, Scendesmus, Pediastrum, Hydrodictyon, Ulva, Enteromorpha, Drapernaldiopsis, 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,*

BSC106 Paper VI LABORATORY COURSE II

Study and identification with suitable preparations of the following:

A. PTERIDOPHYTES
Psilotum, Isoetes, Ophioglossum, Botrychium, Osmunda, Gleichenia, Polypodium, Azolla, Salvinia and important fossil types.

B. GYMNOSPERMS
Cycas, Zamia, Ginkgo, Abies, Picea, Cedrus, Cryptomeria, Cupressus, Podocarpus, Cephalotaxus, Agathis, Araucaria, Taxus, Ephedra and *Gnetum.*

C. PALAEOBOTANY

1. Study of available fossil flora through specimens and slides, etc.
2. 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.
3. Description of a species based on various specimens to study intra specific variation.
4. Studies to find out the location of key characters and preparation of keys at generic level.
5. 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.
6. Comparison of different species of a genus and different genera of a family to calculate

Similarity coefficients and preparation of dendrograms.

SEMESTER II

BSC107. 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 (4^{th} 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. Unnin 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 (5^{th} edition). Worth, New York.
21. Salisbury, F.B. and Ross, C.W. 1992. Plant Physiology (4^{th} edition). Wadsworth Publishing, Belmont, California.
22. Steeves, T.A. and Sussex, I.M. 1989. Patterns in Plant Development (2^{nd}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.

BSC 108. 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, sweat 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. Status of IPRs in India concerning plants, agricultural crops and varieties.
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.
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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 Serdong, 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.

BSC109. 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: Mapping the bacteriophage genome, phage phenotypes; genetic recombination of phage; genetic transportation, conjugation ant 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; Initiatiion 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.
15. Alien gene transfer through chromosome manipulations: Transfer of whole genome, examples from wheat, groundnut and mustard; transfer of individual chromosome and chromosome segments.

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.

BSC110. 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; selection, clonal selection.
2. Hybridization: Interspecific and inter generic; pure line; back cross hybridization; self-incompatibility system.
3. Heterosis: Its genetic and physiological basis; economic exploitation of heterosis in maize.
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,
7. New York.

BSC 111 Paper X I 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,* etc.).
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 embryosac 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. Gums, resins, tannins and dyes: Perform simple tests for gums and resins.
To prepare a water extract of vegetable tannins (*Acacia, Terminalia, Camellia, Cassia*) and dyes (*Curcuma longa*, *Bixa orellana, Indigofera*, *Butea monosperma*, *Lawsonia inermis, etc.).*

BSC112 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. Restrictioin digestion of plant DNA, its seperation 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 (2^{nd} edition). John Willey & Sons Inc., USA.

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

SEMESTER III

BSC 113. Paper XIII: PLANT PHYSIOLOGY AND BIOCHEMISTRY

1. Functional aspects of plant cell structure: colloidal systems, diffusion, osmosis and imbibition.
2. Energy flow: Principles of thermodynamics, free energy and chemical potential, redox reactions, structure and functions of ATP.
3. Fundamentals of enzymology: General aspects, 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.
5. Photochemistry and photosynthesis: General concepts and historical background, evolution of photosynthetic apparatus, photosynthetic pigments and light harvesting complexes, photo oxidation of water, mechanism of electron and proton transport, carbon assimilation – the Calvin cycle, photorespiration and its significance, the C_4 cycle, the CAM pathway, biosynthesis of starch and sucrose, physiological and ecological considerations.
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, structure and function of lipids, fatty acid biosynthesis, lipids synthesis, structural and storage lipids, and their catabolism.
7. Nitrogen fixation, nitrogen and sulphur metabolism: Overview, biological nitrogen fixation, nodule formation and nod factors, mechanism of nitrate uptake and reduction, sulfur uptake, transport and assimilation.
8. 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 (4^{th} 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 (2^{nd} 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.

BSC 114. Paper XIV ECOLOGY AND REMOTE SENSING

1. Climate, soil and vegetation pattern of the world: Life zones; major biomes, major vegetations and soil types of the world.
2. Vegetation organization: Concepts of community and continuum; analysis of communities (analytical and synthetic characters); community coefficient; interspecific associations; ordination; concept of ecological niche.
3. 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.
4. 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), global biogeochemical cycles of C, N, P and S; mineral cycle (pathways, processes, budgets) in terrestrial ecosystems.
5. 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.
6. Air, water and soil pollution: Kinds; sources; quality parameters; effects on plants and ecosystems.
7. Climate change: Greenhouse gases (CO_2, CH_4, N_2O, CFCs; sources, trends and role); Ozone layer and ozone hole; consequences of climate changes (CO_2 fertilization, global warming, sea level rise, UV radiation).
8. 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.
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:

1. Barbour, M.G., Burk, J.H. and Pitts, W.D. 1987. Terrestrial Plant Ecology. Benjamin/ Cummings Publication Company, California
2. Begon, M., Harpor, J.L. and Townsend, C.R. 1996. Ecology. Blackwell Science, Cambridge, U.S.A.
3. Chapman, J.L. and Reiss, M.J. 1988. Ecology: Principles and Applications. Cambridge University Press, Cambridge, U.K.
4. Heywood, V.H. and Watson, R.T.1995. Global Biodiversity Assesment. Cambridge University Press.
5. 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.
6. Odum, E.P. 1983.Basic Ecology. Saunders, Philadelphia
7. Smith, R.L. 1996. Ecology and Field Biology. Harper Collins, New York.

BSE 115 Paper XVa. 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, transfaction 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.

BSE 115. Paper XV b. ECOSYSTEM ANALYSIS, GIS AND REMOTE SENSING ANALYSIS

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 planningon).
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 instruction 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.l. 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.

BSE 115. Paper XV c: 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: PlantForm, 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 andManagement. Academic Press, New York.

BSE 115. Paper XV d. 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

BSE 115. Paper XV e: 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:** AeroalIergens, 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. Essentails of Palynology; Asia Publication House Lucknow.
5. Woodhouse, R.P. 1935. Pollen Grains: Hafner Publication Co.

BSE 115. Paper XV f: 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 incompatability; 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.

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 hydrophonics. Israel Univerisity, 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.

BSE 116 Paper XVIa. PLANT HEALTH MANAGEMENT

1. Basic procedure in diagnosis of plant diseases: Significance of plant diseases. Effects of changes in agricultural methods and human society on the development and spread 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.

BSE 116 . Paper XVI b. 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, Bolbiteaceae, Boudarzewiaceae, Cortivariaceae, 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, hydnoid 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.

BSE 116. Paper XVIc ENVIRONMENT MANAGEMENT AND BASICS OF NANOTECHNOLOGY

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.
11. Introduction to nanotechnology and nanomaterials, special nanomaterials.
12. Synthesis of nanomaterials: Physical methods (Mechanical and vapour), chemical methods (colloids, sol-gel, Langmuir- Blodgett films, microemulsion), biological methods (using biomembranes, DNA, enzymes and micro organisms). Properties of nanomaterials, mechanical, structural, electrical, optical, magnetic and melting properties.
13. Analytical techniques- Microscopes, electron microscopes, scanning probe microscopes (SPM), Diffraction techniques, Spectroscopy, magnetic measurements.
14. Application of nanotechnology in tissue repair, biotechnology, medical fields and cleaning up environment.

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.
6. Kulkarni, Sulabha. S. 2007. Nanatechnology: Principles and Practices. Capital Publishing Co. New Delhi.

BSE 116. Paper XVI d. 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-dimenstional 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. & Quellette, 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.enseml.org

Paper XVIe: 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.

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

XVI f: 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, micro-fibril 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. Fahn, A. Plant Anatomy. Pergamon Press.

BSC 117 XVII LABORATORY COURSE I

A. Practical Exercises based on BSC 113

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 determine the chlorophyll a/chlorophyll b ratio in C_3 and C_4 plants.
8. To study the effect of time and enzyme concentration on the rate of reaction of enzyme (acid phosphatase, nitrate reductase).
9. To study the effect of substrate concentration on activity of any enzyme and determination of its Km value.
10. To separate the amino acids by paper chromatography.
11. Principles of colorimetry, spectrophotometry and flourimetry.

B. Practical Exercises based on BSC 114

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 ($\propto$) 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.

BSE 118. LABORATORY COURSE II
(Based on elective papers)

XVa:

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.

XVb:

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

XVc:

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.

XVd:

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.

XVe:

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.

XV f:

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.

XVIa:

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.

XVIb:

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.*
7. DNA Isolation, amplification and ITS, RELP, RAPD analysis, DNA primers and markers. PCR and Gel electrophoresis.

XVIc:

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.

XVId:

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.

XVIe:

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.

Manual for Laboratory Exercises:

1. Srinivas, P., Singh, K.P. and Bijendra Kumar. Laboratory Manual on Seed Pathology. GB Pant University of Agricultural Science and Technology, Hill Campus, Ranichauri. Vikrant Offset, Haldwani.

XVI f:

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.

SEMESTER IV

BSC 119. PAPER XIX: 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 Straegies, Gyanodaya Prakashan, Nainital
3. Groombridge, B. and Jenkins, M.D. 2000. Global Biodiversity. Earth's living resources in the 21th 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.

BSC 120 Paper XX 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 embryogenisis: 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 throughout 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-Lioyd, 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, Landon, 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.

BSC. 121 XXI. 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.

Dissertation/ Project Work

Dissertation is an elective one mandatory for every student. 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	:	20 Marks
Dissertation	:	60 Marks
VivaVoce	:	20 Marks
Total	:	100 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

SYLLABUS

HNB GARHWAL UNIVERSITY, SRINAGAR-GARHWAL
2011-2012 ONWARDS
Department of Botany and Microbiology
Master of Science
2. MICROBIOLOGY

(Two Year Course- Semester System)

Admission of the Master's Program in Microbiology shall be through entrance examination conducted by the University and the program shall be based on the choice based 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 Microbiology after he/she has successfully completed a three year undergraduate degree or earned prescribed number of credits through the examinations conducted by University as equivalent to an undergraduate degree. The fee structure would be as per University ordinances for Professional Courses but the fee once deposited by the candidate would not be refundable under any circumstances barring security fee.

Core courses prescribed for every Semester shall be mandatory for all students registered for the Master's Program in Microbiology and shall carry minimum 54 credits. 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.

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 disciplines/departments and one qualifying self study course of minimum 03 credits.

The dissertation is an elective course and is mandatory for every student. The dissertation would be allotted in the beginning of the III Semester and the candidate would submit the report during IV Semester examination. The dissertation may be in the form of a minor Research Work/ Project work/ Practical Training or Field Work. The students may complete the dissertation work in the Department/ other Research Institutes/ Industries/ Hospitals, etc.

M. Sc. Semester I

Code	Paper	Credit
MBC101	Bacteriology	03
MBC102	Virology	03
MBC103	Mycology & Phycology	03
MBC104	Biochemistry & Microbial Physiology	03
MBC105	Laboratory Course I**	03
MBC106	Laboratory Course II	03

Core Credits= 18

M. Sc. Semester II

Code	Paper	Credit
MBC107	Molecular Biology & Microbial Genetics	03
MBC108	Medical Microbiology	03
MBC109	Immunology	03
MBC110	Food Microbiology	03
MBC111	Laboratory Course I	03
MBC112	Laboratory Course II	03

Core Credits= 18 with additional 03 Credits of Self Study (Seminar)

M. Sc. Semester III

Code	Paper	Credit
MBC113	Environmental Microbiology	03
MBC114	Industrial Microbiology	03
MBE115	a. Recombinant DNA Technology b. Soil Microbiology c. Elective offered by other Department	03
MBE116	a. Cellular Microbiology b. Ecology c. Elective offered by other Department	03
MBC117	Laboratory Course I	03
MBE118	Laboratory Course II	03

Core Credits 09+ Elective Credits 09; Total Credits= 18+ 03 Credits of Self Study

M. Sc. Semester IV

Code	Paper	Credit
MBC119	Microbial Diversity including Extremophiles	03
MBC120	Biostatics & Computer Application	03
MBC121	Laboratory Course I	03
MBE122	Dissertation	09

Core Credits 09+ Elective Credits 09; Total Credits= 18+ 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 (Seminar)

* 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.

SEMESTER I

MBC101 Bacteriology

Unit I
History of Microbiology, Difference between prokaryotic and eukaryotic organisms, spontaneous generation vs biogenesis, morphology and ultra structure of bacteria, structure and properties of cell wall of eubacteria and archaebacteria. L-forms. Cell wall synthesis, capsule types, composition and function. Structure and function of flagella, cilia pili, gas vesicles, chromosomes, carboxysomes, magnetosomes and phycobilisomes, nucleoid, cell division, spores, reserve food materials-polyhydroxybutyrate, phosphate granules, oil droplets, cynophysin granules and sulfur inclusion.

Unit II
Methods in Microbiology: Pure culture techniques, sterilization techniques, principle of microbial nutrition, preparation of culture media, enrichment culture techniques for isolation of bacteria. Cultivation of bacteria- aerobic, anaerobic, shaker and still, growth curve, generation time, growth kinetics, asynchronous and synchronous growth. Batch and continuous cultures. Measurement of growth, factor affecting growth. Preservation methods. Control of bacteria-physical and chemical agents.

Unit III
Microbial evolution, Basic principle and techniques used in bacterial classification, classification of microorganisms- Haeckel's three kingdom concept, Whittaker's five kingdom concept, eight kingdom classification, three domain concept of Carl Woese. Bergey's system of bacterial classification, brief account of Gracilicutes, Fermicutes, Mendosicutes and Tenericutes. Phylogenetic and numerical taxonomy.

Unit IV
Characteristic features and taxonomic characterization of Archaebactreia; photosynthetic eubacteria (Cyanobacteria, Purple and Green bacteria); Chemoautotrophic and methophilic bacteria; Gram negative aerobic eubacteria (*Pseudomonas*, *Rhizobium*, Azotobacter, Acetic acid bacteria etc.); gliding bacteria (Myxobacteria, Cytophaga group etc); Enteric group and related eubacteria.

Unit V
Characteristic features and taxonomic characterization of Gram negative anaerobic eubacteria (*Veillonella*, *Megasphaera*, *Bacteroids*, *Fusobacterium* etc and Sulfur-reducing bacteria), Gram negative eubacteria (Spirochetes, Rickettsias and Chlamydias); Gram positive unicellular endospore formers; Gram positive fermentative eubacteria (Staphylococcus, Lactic Acid Bacteria etc); Gram positive eubacteria (Actinomycetes); the Mollecutes (Mycoplasma etc.).

Suggested Reading:

1. Pelczar, M.J., E.C.S. Chan & N.R. Kreig. Microbiology. Mc Graw Hill.
2. Prescott, L.J., J.P.M. Harley & A.D. Klein. Microbiology. Wm. C. Broun Publisher.
3. Stanier,RY., JL Ingraham, ML Wheelis. General Microbiology. MacMillan Press.
4. Sclegel, H.G. General Microbiology. Cambridge University Press.
5. Bridge, E.A. Modern Microbiology. WMC Brown Publisher, Oxford England.
6. Guinsales, I., Stanier R.Y. The Bacteria. Vol. I, II and III. Academic Press.
7. Brock, T.D., & MT Madigen. Biology of Microorganisms. Printise Hall Inc.
8. Dubey, R.C. & D.K. Maheshwari. A text Book of Microbiology. S. Chand & Co. N. Delhi.

MBC102 Virology

Unit I

General Virology: Brief outline of discovery of viruses, nomenclature and classification of viruses. Morphology and ultrastructure, capsids and their arrangements, types of envelopes and their compositions. Viral genome, their types and structures. Virus related organisms (viroids, virusoids and prions). Cynophages: morphology, growth cycle. Mycoviruses.

Unit II

General methods of diagnosis and serology: isolation and cultivation of viruses. Experimental animals and cell culture. Primary and secondary cell culture, suspension of cell culture and monolayer cell culture, cell strain, cell lines and transgenic systems. Serological tests, Haem Agglutination and HAI, complement fixation, immunofluorescence methods. ELISA and RIA, NASH using probes. Assay of viruses- physical and chemical methods (protein, nucleic acid, radioactivity tracers, electron microscopy). Infectivity assay (Plaque method, end point methods), infectivity assay of plant viruses.

Unit III

Bacterial viruses: Bacteriophage structural organization, life cycle, one step growth curve, transcription , DNA replication, eclipse phase , phage production , burst size, lysogenic size, bacteriophage typing, application in bacterial genetics, brief details on M13, Mu, T4, Lembda.

Unit IV

Plant viruses: Classification and nomenclature, symptoms, viral structure, protein synthesis, effects of viruses on plants, histology, physiology and cytology of plants. Common viral diseases of plants- paddy, cotton, tomato, and sugarcane. Type species of plant viruses like TMV, cauliflower mosaic virus and potato virus X. Transmission of plant viruses with vectors (insects, nematodes, fungi) and without vectors (contact, seed dodder, and pollens). Preservation of crop loss due to virus infection, virus free planting material, vector control.

Unit V

Animal viruses: Classification and nomenclature of animal viruses, multiplication of animal viruses, epidemiology, lifecycle pathogenecity, diagnosis, prevention and treatment of RNA viruses-Picorna, Orthomyxo, Retrovirus, Adenoviruses, Toga and other anthropods viruses,

Rhabdo, Rota, HIV, and other oncogenic viruses. DNA viruses-Pox, Herpes, SV40, Hepatitis. Interferon and antiviral drugs.

Suggested Reading:

1. Morag, C. & M.C. Timbury. 1994. Medical Virology. Churchill Livingstone, London.
2. Dimmoc, N.J., P.C. Primrose. 1994. Introduction to modern virology. Blackwell Scientific Publications, Oxford.
3. Conrat, H.F., P.C. Kimbell & J.A. Levey. 1994. Virology. 3rd ed. Prentice Hall.
4. Mathews, R.E. 1992. Functionals of plant virology. Academic Press, San Diego.
5. Topley & Wilson. 1995. Text book on principles of bacteriology, virology and immunology. Edward Arnold, London.

MBC103 Mycology and Phycology

Unit I

Historical introduction to mycology, structure and cell differentiation. Classification, general features, mycelial organization and structure, nutrition and reproduction in fungi. Salient features of divisions- Myxomycota: Acrasiomycetes, Hydromyxomycetes, Myxomycetes, Plasmodiophoromycetes; Mastigomycotina (Zoosporic fungi): Chytridiomycetes, Hypochytridiomycetes, Oomycetes; Zygomycotina: Zygomycetes, Trichomycetes. Evolutionary tendencies in lower fungi.

Unit II

Salient features of: Ascomycotina- hemiascomycetes, plectomycetes, pyrenomycetes, discomycetes, leboulbeniomycetes, loculoascomycetes; Basidiomycotina- teliomycetes, hymenomycetes, gastromycetes; Deutromycotina- hypomycetes, coelomycetes, blastomycetes. Economic importance. Plants diseases- *Pythium* seed rot, grapes downy mildew, potato early and late blights, tomato- fusarial wilt, wheat-smut and rust. Animal diseases- mycoses; systemic and subcutaneous, candidiasis, pnemocystis, blastomycoses, dematophytoses.

Unit III

Heterothallism, sex hormones in fungi, Physiological specialization, Saxuality in ascomycetesphylogeny of fungi. Lichens- ascolichens, basidiolichens, deutrolichens. Mycorrhiza- ectomycorrhiza, endomycorrhiza, vesicular arbuscular mycorrhiza. Fungi as insect symbionts. Fungi and ecosystem: saprophytes, substrate groups, and nutritional strategies, substrate successions; fungi and bioremediation. Attack on fungi by other microorganisms and antifungal agents.

Unit IV

Distribution of algae, ecology, cytology, basis of classification of algae, various systems of classification, thallus structure, nutrition, reproduction, life cycle in algae and their types, Laboratory culture and staining, fossil records of algae.

Unit V

Distinguishing characters, classification of Myxophyceae, Chlorophyceae, Xanthophyceae, Bacillariophyceae, Phaeophyceae and Rhodophyceae. Conflicts on classification of Myxophyceae, specialized structure of Myxophyceae (Hormogones, Homocyst, Endospore, Exospore, Nanocyst, Akinetes, Heterocysts), nitrogen fixation in myxomycetes, Taxonomic treatment of myxophyceae (cyanobacteria) in Bergey's Manual. Economic aspects of algae and algal biotechnology.

Suggested Reading:

1. Mehrotra, R.S. & K.R. Aneja. 1990. An introduction to mycology. New Age International.
2. Burnett, J.H. Fundamentals of Mycology. Publisher: Edward, Arnold, Crane Russek.
3. Charlie, M., & S.C. Watkinson. The Fungi. Academic Press.
4. Alexopoulos C.J. & Mims C.J. 3rd ed. Willey Eastern Ltd. N. Delhi.
5. Sharma, O.P. Algae. Pragati Prakashan.
6. Vashishth B.R. Algae. S. Chand & Co.

MBC104 Biochemistry & Microbiology Physiology

Unit I

General structural features and chemistry of macromolecules; nucleic acid, proteins, carbohydrates and lipids and biomolecules such as vitamins, antibiotics, pigments, alkaloid and toxins. Structure of chromatin and chromosomes, heterochromatin and euchromatin. Stabilizing interactions (Van der Walls, electrostatic, hydrogen bonding, hydrophobic interaction, etc.); principles of biophysical chemistry (pH, buffer, reaction kinetics, colligative properties, etc). Structure of biological membrane, diffusion, osmosis, ion channels, active transport, ion pumps, mechanism of regulation of intracellular transport, electrical properties of membrane

Unit II

Enzymes: Enzyme nomenclature, enzyme commission numbers and classification of enzymes. Enzyme activity, Specific activity and turn over number, isozyme. Enzyme kinetics: Michaelis-Menton equation for simple enzymes, determination of kinetic parameters. Multistep reaction and rate limiting steps. Effects of pH and temperature on enzyme action, enzyme inhibition, allosterism, Kinetic analysis of allosteric enzymes, Principles of allosteric regulation (Simple Sequential Model and Concerted Model).

Unit III

Brief account of bacterial photosynthesis, classification of photosynthetic bacteria, photosynthetic pigments, Chlorophyll, bacteriochlorophyll, rhodopsin, carotenoid, phycobilliproteins. Autotrophy, oxygenic and anoxygenic photosynthetic bacteria and their mechanism. Photosynthetic electron transport system, photophosphorylation, dark reaction, C_3, C_4 pathways. Chemolithotrophy- sulfur, iron, hydrogen, nitrogen oxidations, methanogenesis.

Unit IV

Principles of energy production: Oxidation-reduction reactions, coupled reaction and group transfer, the respiratory chain, energy production by anaerobic processes (Glycolysis, PP Pathway, ED pathway, fermentation); energy production by aerobic processes (TCA cycle, aerobic respiration, respiration without O_2 in bacteria, heterotrophic CO2 fixation, glyoxylates cycle); energy production by photosynthesis (cyclic and non-cyclic photophosphorylation); the mechanism of ATP synthesis; utilization of energy in biosynthesis and non-biosynthetic processes.

Unit V

Microbial metabolism: Catabolism of carbohydrates, lipids, proteins, and nucleic acids. Anabolism of amino acids, proteins, nucleic acids, lipids and carbohydrates. Vitamins and their role as coenzymes. Assimilation of nitrogen- dinitrogen, nitrate nitrogen, ammonia assimilation.

Suggested Reading:

1. Caldwell, DR. Microbial Physiology & Metabolism. 1995. Brown Publishers.
2. Moat & Foster. Microbial Physiology. 1999. Wiley.
3. Stanier, R.Y., J.L. Grahm, M.L. Wheelis & P.R. Painter. General Microbiology. 1986. McMillan.
4. Burn, Y.V. & L.J. Shimkets. Prokaryotic Development. 2000. ASM Press.
5. Stryer. 2001. Biochemistry. 5th ed. WH Freeman.
6. Nelson & Cox. 2002. Lehinenger Principles of Biochemistry. 3rd ed. Worth Publisher.
7. Harpers Biochemistry. 1999. McGraw Hill.
8. Jain, J.L. Biochemistry. S. Chand & Co.

MBC105 Laboratory Course I

1. Isolation of bacteria and actinomycetes from given sample.
2. Biochemical characterizations used in the identification of bacterial isolates.
3. Various types of bacterial cell staining (Simple staining, Gram Staining, Negative Staining, Acid Fast Staining etc.).
4. Staining of spore and flagella.
5. To determine the motility of bacteria.
6. Determination of size of bacterial cell using Micrometer.
7. To perform preservation methods of bacterial cultures.
8. To determine the growth curve of bacteria.
9. Collection, symptomatology and identification of Plant viruses on beans, papaya, potato, tobacco, etc.
10. Isolation of bacteriophage and determination of Plaque Forming Unit (PFU).
11. Isolation of cyanophage and determination of Plaque Forming Unit (PFU).
12. Determination of one step growth curve of viruses.
13. Determination of burst size of virus.

MBC106 Laboratory Course II

1. Isolation and identification of fungi from given sample.
2. Isolation of aquatic fungi using bait technique.
3. Isolation and identification of various plant pathogens.
4. To perform preservation methods of bacterial cultures.
5. Isolation and purification of cyanobacteria.
6. Educational trip for mushroom collection (Mushroom Hunting) in monsoon season. Spore printing and identification of mushroom.
7. Estimation of protein using Lowry or Biurate method.
8. Estimation of sugar concentration in given sample.
9. Estimation of lipid concentration in given sample.
10. Determination of isoelectric point of amino acid.
11. Determination of enzymatic activity and Km value.
12. Study of red light induced akinete formation in cyanobacteria.
13. Determination of catalase and oxidase activity of given bacteria.
14. Study of sugar fermentation by bacteria.
15. Study of red light induced akinete formation in cyanobacteria.
16. Determination of catalase and oxidase activity of given bacteria.
17. Study of sugar fermentation by bacteria.
18. To study of effect of pH, temperature and salt concentration on bacterial growth.

SEMESTER II

MBC107 Molecular Biology & Microbial Genetics

Unit I

Nucleic acids as genetic information carrier: Experimental evidence. DNA structure, Historical aspects and current concepts. Melting of DNA, DNA replication; general principles, various modes of replication; isolation and properties of DNA polymerase, proof reading, continuous and discontinuous synthesis, Inhibitors of DNA replication (Blocking precursor synthesis, nucleotide polymerization, altering DNA structure). Asymetric and dimeric nature of DNA polymerase, exonuclease activity in eukaryotic DNA polymerases.

Unit II

Gene as a unit mutation and recombination. Molecular nature of mutations. Mutagens. Spontaneous mutation origin. DNA damage and repair: type of DNA damage (deamination, oxidative damage, alkylation, pyridine dimers). Repair pathways- methyl directed mismatch repair, very short patch repair, nucleotide excision repair, base excision repair, recombination repair. SOS system.

Unit III

Structural features of RNA (rRNA, tRNA & mRNA) and relation of function. Initiator and elongator class of tRNA, ribosome binding site on mRNA and corresponding site on rRNA. Peptidyltransferase activity of 23S rRNA. Transcription: general principles, basic apparatus, type of RNA polymerases, Mechanism of transcription in prokaryotes and eukaryotes, steps; initiation, elongation and termination. Inhibitors of RNA synthesis. Polycistronic and monocystronic RNAs. Basic features of genetic code. Protein synthesis and its step; initiation, elongation and termination. Inhibitors of protein synthesis. Translational mechanism in prokaryotes and eukaryotes, Post translational modification and transport, Protein targeting (signalling). Non ribosomal polypeptide synthesis.

Unit IV

Gene transfer mechanisms- transformation, transduction, conjugation and transfection, mechanism and applications. Plasmids: F factor description and their use in genetic analyses. Colicine and col factors. Plasmid as vectors for gene cloning. Replication of plasmids-compatibility. Bacteriophases: Lytic phages-T4. Lysogenic phage lambda and P1, M13 and ϕX 174. Life cycle and their uses in microbial genetics.

Unit V

Regulation of Gene Expression in Prokaryotes and Eukaryotes: Operon concept, Positive and negative control, Structure and regulation of *lac*, *trp* and *arb* operon, regulation of gene expression in eukaryotes (a brief account), anti-sense RNA, RNAi, Gene conversion, site specific recombination, transposable elements, nomenclature, insertation sequences, transposons (structure, mechanism and genetics of transcription).

Suggested Reading:

1. Lewin. Genes V, VI, VII, VIII & IX. Oxford University Press.

2. Lodish, B. & Zippursky. Molecular Cell Biology. W. H. Freeman.
3. Gardner et al. Principles of Genetics. John Willy & Sons.
4. Friefelder. Microbial Genetics. Jones & Bartlett Pub., Boston.
5. Stryer. 2001. Biochemistry. 5th ed. WH Freeman.
6. Nelson & Cox. 2002. Lehinenger Principles of Biochemistry. 3rd ed. Worth Publisher.

MBC108 Medical Microbiology

Unit I

Early discovery of pathogenic microorganisms, development of bacteriology as scientific discipline, contribution made by eminent scientists. Classification of medically important microorganisms. Normal micro flora of human body, role of resident flora and the human host. Epidemiology: Disease cycle (sources of disease. Reservoirs & carriers). Transmission of Pathogens, routes of infection. Primary & secondary infections, epidemic, endemic, pandemic.

Unit II

Establishment, spreading, tissue damage & antiphagocytic factors. Mechanism of Bacterial adhesion, colonization & invasion of mucus membranes of respiratory, enteric & urogenital tracts. Role of aggresins, depolymerizing enzymes, organotrophisms, variation & virulence. Organs & cells involved in immune system & immune response.

Unit III

Classification of pathogenic bacteria *Staphylococcus, Streptococcus, Pneumococcus Neisseria, Cornybacterium, Bacillus, Clostridium*. Non sporing anaerobes, organism belonging to Enterobacteriaceae, vibrios non fermenting gram negative bacilli, *Yersinia, Haemophillus, Bordetella, Brucella, Mycobacterium*, Spirochaetes, Actinomycetes, Rickettsiae, Chlamydiae.

Unit IV

General properties of viruses. Viruses host interactions. Pox viruses, Adeno viruses, Picorna viruses, Orthomyxo viruses, Paramixo viruses, Arbo viruses, Rhabdo viruses, Hepatitis viruses, Oncogenic viruses, HIV. Fungal diseases: Dermatophytes, Dimorphic fungi, opportunistic fungal pathogens- Candidiasis, Pneumocystis, Blastomycosis, Histoplasmosis.

Unit V

Protozoal infection: Plasmodium, Trypanosoma, Entamoeba, Balantidium, Pneumocystis. Laboratory control of antimicrobial therapy- various methods of drug susceptibility testing, action of antibiotics & drug resistance, antibiotic assay in body fluids. Brief account on available vaccines & schedules, passive prophylactic measures. Common types of hospital infections & their diagnosis & control. Different staining techniques such as Leffer's polychrome methylene blue & negative staining, Fluorochrome staining, Leishman's staining, Giemsa's staining etc.

Suggested Reading:

1. Ananthanarayan & Panicker. 1997. Text Book of Microbiology. Orient Longman.

2. Mackie & McCartney. Medical Microbiology. Vol.1. Microbial infection. Vol.2. Practical Medical Microbiology. Churchill Livingston.
3. Shanson, D.C. & Wright, PSG. Microbiology in clinical Practice. 1982.
4. Baron. E.J., Peterson L.R. & Finegold, S.M. Bailey & Scott's Diagnostic Microbiology. 1990. Mosby Publ.
5. Murrey, P.R., Rosenthal, K.S., Kobayashi, G.S. & Pfaller, M.A. Medical Microbiology. Mosbay Publ.

MBC109 Immunology

Unit I
Immunity system and immunity: History of immunology, composition and functions of cells and organs involved in immune system. Immune response- innate immunity, acquired immunity. Determinants of innate immunity: species and strains, individual differences, influence of age, hormonal influence, nutritional factors, and mechanical barriers and surface secretions. Non specific immune mechanisms: surface defenses, tissue defenses, opsonization, inflammatory reactions, hormonal balance.

Unit II
Antigens and antibodies: Antigens- structure and properties, types, iso and allo haptens, adjuvents, antigens specificity. Immunoglobulin- structures, heterogeneity, types and subtypes, properties (Physiochemical and biological). Theories of antibody production Complements- Structure, components, properties and functions of different components. Complement pathways (Classical, alternate and lectine pathways) and biological consequences of complements activation. Antigen- antibody reactions: in vitro methods- Agglutination, precipitation. Complement fixation, immunofluorescence, ELISA, Radio immuno assay.

Unit III
Lymphocytes, their sub population, their properties and functions. Membrane bound receptors of lymph cells. Helper T cells in immune response. T cell suppression in immune response. Development and differentiation of B and T cells. recognition of antigens by T & B cells, T – cell receptor complex, B– cells receptor complex. Mechanisms of cell mediate immunity, immune tolerance to self antigen. monoclonal antibodies (hybridoma technology), recombinant antibodies, class-switching.

Unit IV
Major Histocompatibility Complex (MHC) and Tumor Immunology: Structure and functions of MHC and HL-A system. Gene regulation and Ir-genes. HLA and tissue transplantation, graft vs. host reaction and rejection, immune suppression-specific and non specific autoimmunity-theories mechanisms and diseases. Tumor immunology- tumor specific antigens, immune response to tumor.

Unit V
Hypersensitivity reactions: antibody mediated type I, Anaphylaxis type II, antibody dependent cell cytotoxicity, type III, immune complex mediate reactions, type IV cell mediated

hypersensitivity reactions. cytokines, Defects in immune system: primary and secondary defects, defects in complements, defective phagocyte mechanisms.

Suggested Reading:

1. Roitt, I.M. 1998. Essentials of Immunology. ELBS, Blackwell Scientific Pub.
2. Kuby, J. 1994. Immunology. IIed. W.H. Freemen & Company, New York.
3. Klaus D. Elgert. 1996. Immunology: Understanding of Immune System, Willy.
4. Christopher & David. Principle & Practice of Immunoassay 2nd Ed. –
5. Tizard, I.R. Immunology – An Introduction (2004). Thompson Pub.

MBC110 Food Microbiology

Unit I

Food as substrate for microorganisms: Microorganisms important in food microbiology- Molds, Yeast and Bacteria, general characteristics, classification and importance, principles of food preservation. Asepsis- removal of microorganism, (anaerobic conditions, high temperature, low temperatures, dying). Factors influencing microbial growth in food, extrinsic and intrinsic factors; chemical preservatives and food additives. Canning, processing for heat treatment-D, Z, and F values and working out treatment parameters.

Unit II

Contamination and spoilage: Cereals, sugar products, vegetables, fruits, meat and meat products, milk and milk products, fish and sea foods, poultry. Spoilage of canned foods. Detection of spoilage and characterization.

Unit III

Food bourn infections, intoxications: bacterial and nonbacterial with examples of infective and toxic types- *Brucella, Bacillus, Clostridium, Escherichia, Salmonella, Shigella, Staphylococcus, Vibrio, Yersinia,* nematodes, protozoa, algae, fungi and viruses. Food born outbreaks, laboratory testing procedures, prevention measures, food sanitation in manufacture and retail trade, food control agencies and its regulations. Aflatoxins- structures and function.

Unit IV

Food fermentations: bread cheese, vinegar, fermented vegetables, fermented dairy products. Experimental and industrial production methods. Spoilage and defects of fermented dairy products, oriental fermented foods, their quality standards and control (HACCP and ISO standards).

Unit V

Food produced by microbes: fermented foods, microbial cells as food (single cell proteins), mushroom cultivation. Bioconversions; production of alcohol, fermented beverages- beer and wine. Steroid conversion, industrial enzymes production- amylase, proteinase, cellulases. Amino acid, glutamic acid and lysine productions. Oriental foods: Mycoprotein, Tempeh, Soya Sauce, Idli, Natto and Poi. Alcoholic or non-alcoholic beverages of Himalayan Region.

Suggested Reading:

1. Adams, M.R., & M.O. Moss.1995. Food Microbiology. Royal Society of Chemistry Publication, Cambridge.
2. Frazier, W.C. & D.C.Westhoff. 1988. Food Microbiology. Tata Mc Graw Hill.
3. Stanbuty, P.F., & S.J. Hall. 1995. Principles of Fermentation Technology. Pergamon Press.
4. Banwart, G.J. 1989. Basic Food Microbiology. CSB Publication.
5. Hobbs, B.C. & Roberts, D. 1993. Food Poisoning & Food Hygiene. Edward Arnold (a division of Hodder & Stughton), London.
6. Robinson, R.K. 1990. Dairy Microbiology. Elsevier Applied Sciences, London.

MBC111 Laboratory Course I

1. Isolation of plasmid and chromosomal DNA from bacteria culture.
2. Digestion of bacterial DNA using restriction enzymes.
3. Electrophoresis of DNA and proteins.
4. To perform DNA ligation reaction.
5. Demonstration of transformation of bacteria.
6. UV induced mutation and demonstration of photo and dark repair in bacteria.
7. Isolation of antibiotic resistant bacteria.
8. Isolation of UV induced auxotrophic mutants by replica plating technique.
9. Demonstration of Polymerase Chain Reaction (PCR).
10. Isolation of *Shigella* and *Salmonella* sp. and *Staphylococcus* sp. from given samples.
11. Preliminary identification of enteric pathogens using IMVIC and Tripal Sugar Iron Agar (TSIA) medium.
12. Estimation of urinary tract infecting bacteria.
13. Demonstration of Koch's postulates.
14. Determination of antibacterial susceptibility.
15. Isolation of dermatophytic microflora and their identification.
16. Determination of dental carries susceptibility.
17. Microbiological examination of sputum of TB patient.

MBC112 Laboratory Course II

1. Demonstration of agglutination reaction of bacterial cultures by slide agglutination reaction.
2. Demonstration of precipitin reaction using immunodiffusion or ring test.
3. Determination of blood group and Rh factor.
4. Detection of specific antigen by using ELISA technique.
5. Determination of quality of milk using Methylene Blue Reductase Reaction Test (MBRT).
6. Demonstration of VDRL serological and RPR card tests for syphilis.
7. Detection of specific antigen using ELISA test.
8. Demonstration of the HIV tri DOT test for AIDS patients.

9. Microbiological examination of food.
10. Demonstration of microbial production of curd.
11. Production of wine from fruits or grain.
12. Microbiological examination of traditional beverages of Uttarakhand
13. Observation of spoiled food samples (i.e. rotten egg, food, fruit or spoiled caned food) and isolation of bacteria or fungi

SEMESTER III

MBC113 Environmental Microbiology

Unit I

Aerobiology: Droplet nuclei, aerosol, assessment of air quality, solid liquid impingement methods- brief account of air born transmission of microbes; viruses, bacteria and fungi, their diseases and preventive measures. Aeroallery and aeroallergens. Rumen microbiology.

Unit II

Aquatic microbiology: water ecosystem, types, fresh water (ponds, lakes strams), marine habitats (estuaries, mangroves, deep sea, hydrothermal vents saltpans, coral reefs). Zonations of water ecosystems, upwelling, eutrophication, food chain. Potability of water microbial assessment of water quality, water purification, brief account of major water born diseases and their control measures. Heavy metal tolerance in microbes.

Unit III

Soil microbiology: classification of soil, physical and chemical characteristics, micro flora of soil, bacteria and nematodes in relevance to soil types; rhizosphere, phyllosphere, brief account of microbial interactions, symbiosis, mutualism, commensalisms, competition, amensalism, synergism, parasitism, predation. Biogeochemical cycles and the organisms; carbon, nitrogen, phosphorous and sulfur. Biological nitrogen fixation, nitrogenase enzyme, *nif* genes, symbiotic nitrogen fixation '*Frankia*, *Rhizobium*', nonsymbiotic microbes '*Azotobacter, Azospirilium'.* Vesicular Arbuscular Micorrhizar (VAM), ecto, endo, ectendo mycorrhizae.

Unit IV

Water treatment: wastes, types, solid and liquid wastes characterization, solid-liquid treatment, physical, chemical, biological-aerobic, anaerobic, primary, secondary, tertiary solid waste treatment, saccharification, gasification, composting, utilization of solid wastes- food (SCP, mushroom, yeast), fuel (ethanol, methane), fertilizer (composting), liquid waste treatment- trickling, activated sludge, oxidation pond, oxidation ditch. Subterranean microbes and bioremediation.

Unit V

Positive and negative roles of microbes in environment: Biomineralization, biodegradation of recalcitrant compounds (xenobiotic compounds)- lignin, pesticides. Bioaccumulation of metals and detoxification- biopesticides. Bioremediation of paper, leather, wood, textiles, cosmetics. Metal corrosion, mode of deterioration, organism involved, its disadvantages, mode of prevention. GMO and their impact, microbial plastics.

Suggested Reading:

1. Alexaander, M. 1971. Microbial Ecology. John Willey & Sons.
2. Alexaander, M. 1977. Introduction to Soil Microbiology. John Willey & Sons.
3. Ec, Eldowney, S., & S. Waites. 1993. Pollution: Ecology & Biotreatment. Longman Scientific Technical.
4. Baker, K.H. & D.S. Herson. 1994. Bioremediation. Mc Graw Hill, New York.

5. Marshal, K.C.1985. Advances of Microbial Ecology. Vol 8. Plenum Press.
6. Burns, R.G. & J.H. Slater. 1982. Experimental Microbial Ecology. Blackwell Publ.
7. Vanghan, D. & RE Malcom. 1985 Soil Organic Matter & Biological Activity. Martinus Nighoff W. Junk Publishers.
8. Brock, T.D. & M.T. Madigen. Biology of Microorganisms. Prentice Hall.

MBC114 Industrial Microbiology

Unit I

General considerations: Metabolic Pathways and metabolic control mechanisms, primary and secondary metabolites. Biotechnological innovations in the chemical industry, biocatalyst in organic chemical synthesis, efficiency of growth and product formation, growth stoichiometry, maintenance energy requirement and maximum biomass yield. P/O quotient.

Unit II

Shake flask culture, fermentation in batch culture, microbial growth kinetics, measurement of (cell number, direct and indirect method), growth and nutrient, growth and product formation, heat evolution, effect of environment (temp., pH, High nutrient concentration), media formulation. Sterilization, kinetics of thermal death of microorganisms, batch and continuous sterilization, Stirred tank, airlift fermenter, Fed batch, continuous and immobilized cell reactors. Fermenter design, instrumental and control.

Unit III

Aeration and agitation, oxygen transfer kinetics, concept of Newtonian and Non-Newtonian Fluids, foam and antifoam. Industrial production of antibiotics(b-lactam and refamycin), citric acid, acetic acid, lactic acid, ethanol, enzymes (pectnase, amylase, lipase, protease, cellulase), steroids, Biofertilizers, Biopesticides, mushroom production, fermented food & beverages, Biopolymers.

Unit IV

Industrial strains. Strategies for selection and improvement, preservation and maintenance, aseptic operation and containment of recombinant organisms. Scale up. Product recovery (down stream process).

Unit V

Recombinant molecules: In pharmaceuticals, health, agriculture, industrial sectors, research labs. Determination of purity and activity of over expressed proteins. Over expression conditions, production of inclusion bodies, solubilization of insoluble proteins,

Suggested Reading:

1. Brian Currell, R.C. & Van Dam Mieras. Biotechnological innovations in Chemical synthesis. 1997. Elsevier.
2. Industrial Microbiology. G. Reed (Editor).CBS Publi (AVI Publishing Co.)
3. Demin, A.L. Biology of Industrial Microorganisms.
4. C.L. Hershnergev, S.W. Queener & Q. Hedemen. Genetics and Biotechnology of industrial microorganisms. ASM Press.

5. Crueger & Crueger. Biotechnology. Panima Publ.
6. Adams M.R. & M.O. Moss.1995. Food Microbiology. Cambridge.
7. Frazier, W.C. & D.C. Westhoff. 1988. Food Microbiology. Tata McGraw Hill.
8. Stanbury, P.F., & S.J. Hall. 1995. Principles of Fermentation Technology. Pergamon Press.

MBE115a Recombinant DNA Technology

Unit I

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. 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.

Unit II

Rationale for the design of vectors for the over expression of recombinant proteins: 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. Experiments using model systems: *E. coli, Yeast, Baculovirus, Agrobacterium tumifaciens.*

Unit III

Basic idea of transformation, conjugation and transduction. Introduction of DNA into host cells: Transformation and identification of recombinants, transfaction and identification of recombinants, transformation of non-bacterial cells.

Unit IV

Obtaining clone of a specific gene: the problem of selection, direct selection, methods of identification of clone from gene library. Locating the cloned gene in plasmid and in chromosomes using southern hybridization and chromosome walking. Transcript analysis, regulation of the gene expression and identifying and studying the translation product of a cloned gene (HRT and HART techniques).

Unit V

DNA sequencing methods: Sanger- Coulson method & Maxam- Gilbert method. Automated sequencing. 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 Seientific 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.

MBE115b Soil Microbiology

Unit-I
Soil as a habitat for microorganism: soil genesis. Factors involved in soil genesis. Soil profile, physiochemical properties of soil (mechanical composition of soil, organic matter, soil water & air). Soil microbes- algae, bacteria, actinomycetes, fungi, protozoa & nematodes. Microbial balance in soil. Molecular markers for ecological studies of soil microorganisms.

Unit-II
Rhizosphere & rhizoplane microorganisms: Reasons for increased microbial activity in rhizosphere, composition of root exudates, factors affecting exudation. Rhizosphere microorganisms. Rhizosphere effect. Effect of microflora on host plants. Factor affecting microbial community in soil– soil moisture, organic & inorganic chemicals, Soil organic matter, Types of vegetation & its growth stages, Different seasons.

Unit-III
Biogeochemical cycle: C, N, P, S cycles. Nitrogen fixation- symbiotic & asymbiotic. Significance of nitrogenase & *nif* genes. Phosphate solubilzation & its mechanism. Pesticide degradation in soil. Soil microbial biomass as an index of soil fertility.

Unit-IV
Organic matter decomposition: composition of litter (cellulose, hemicellulose, lignin water soluble components, ether & alcohol soluble components & proteins). Organic matter dynamics in soil- microbial decomposition of cellulose, hemicellulose, lignin. Microbial successions on decomposing litter. Factors affecting organic matter decomposition (litter quality, temperature, areation, soil, pH, inorganic chemicals and moisture).

Unit-V
Microbial interactions: negative interactions- amensalism, competition parasitism & predation (mycoprasitism, mycophagy, nematophagy- predaceous fungi), commensalisms, positive interaction-mutualism. Synergism. Associative symbiosis- symbiosis, cyanobacterial, bacterial (*Rhizobium* legume symbiosis), Actinomycetes (actinorhhizal- Frankia non-legume root symbiosis) & fungal symbiosis- mycorrhiza types & significance of mycorhizza. Bioinoculants– biopesticides & bioinsecticides.

Suggested Reading:

1. Subbarao, N. S. (1994). Soil Microorganisms & Plant Growth. Oxford & IBH Pvt. Ltd. New Delhi.
2. Burges, A. & Raw, F. (1967). Soil Biology. Academic Press, London
3. Vangham, D & Malcolm, R.E. (1985). Soil organic Matter & Biological Activity. Martinus Nighoff, and W. Junk Publishers.

MBE116a Cellular Microbiology

Unit-I

General structure of Cell. Historical origins of cell biology: The discovery of cell, development of the cell theory. Bacterial diseases and emergence of cellular microbiology. Cellular biology underlying prokaryotic & eukaryotic interactions: bacterial ultra structure, gene expression, pathogenicity islands.

Unit-II

Prokaryotic & eukaryotic signaling mechanism: eukaryotic cell to cell signaling, endocrine signaling, cytokines Prokaryotic signaling: quorum sensing & pheromones intracellular signaling. Signaling pathways. Cell signaling: Exocrine, Endocrine, Paracrine and Synaptic strategies of chemical signaling, surface receptor mediated transduction (DAG, Ca+2, c-AMP, G-Proteins)

Unit-III

Infection & cell-cell interaction; bacterial adherence: basic principles, effect of adhesion on bacteria, effect of adhesion on host cell. Bacterial invasion of host cells; mechanism, consequence of invasion, survival after invasion. Protein toxins: classification of toxins, agents of disease.

Unit-IV

Immune response to bacterial infection: innate response: complement, acute phase proteins, macrophages: cytokines & interferon. Acquired immune response, cell mediated immune response, humoral response.

Unit-V

Cellular microbiology future directions: comparative genomics. Functional genomics toolbox, genome evolution in microbes. Cellular microbiology in future direction, web resources for databases.

Suggested Reading:

1. Henderson et. al.,Cellular Microbiology. 1999. Wiley.
2. de Bruijn et. al., Bacterial Genomics. 1998. Chapman & Hall.
3. Dorman C.J. 1994. Genetics of bacterial Virulence. Blackwell.
4. R.C. Dubey & D.K. Maheshwari. A Text book of microbiology. S. Chand Co. 2005.
5. Cooper, G.M. The Cell: A molecular Approach (2004).
6. Lodish et al. Molecular Cell Biology (2004).

MBE116b Ecology

Unit I

Climate, soil and vegetation pattern of the world: Life zones; major biomes, major vegetations and soil types of the world. Vegetation organization: Concepts of community and continuum; analysis of communities (analytical and synthetic characters); community coefficient; interspecific associations; ordination; concept of ecological niche, Niche concept in microbiology.

Unit II

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. Ecosystem organization: Structure and functions; primary production (methods of measurement, global pattern, controlling factors); energy dynamics (trophic organization, energy flow pathways, ecological efficiencies).

Unit III

Litter fall and decomposition (mechanism, substrate quality and climatic factors), global biogeochemical cycles of C, N, P and S; mineral cycle (pathways, processes, budgets) in terrestrial ecosystems.

Unit IV

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. Air, water and soil pollution: Kinds; sources; quality parameters; effects on plants and ecosystems. Climate change: Greenhouse gases (CO_2, CH_4, N_2O, CFCs; sources, trends and role); Ozone layer and ozone hole; consequences of climate changes (CO_2 fertilization, global warming, sea level rise, UV radiation).

Unit V

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. Fire as an ecological factor: Types, role of fire, controlled burning, fire as management tool. Effect of fire on microbiota. Ecological management: Concept; sustainable development, sustainability indicators.

Suggested Readings:

1. Barbour, M.g., Burk, J.H. and Pitts, W.D. 1987. Terrestrial Plant Ecology. Benjamin/ Cummings Publication Company, California.
2. Begon, M., Harpor, J.L. and Townsend, C.R. 1996. Ecology. Blackwell Science, Cambridge, U.S.A.
3. Chapman, J.L. and Reiss, M.J. 1988. Ecology: Principles and Applications. Cambridge University Press, Cambridge, U.K.

4. Heywood, V.H. and Watson, R.T.1995. Global Biodiversity Assessment. Cambridge University Press.
5. 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.
6. Odum, E.P. 1983.Basic Ecology. Saunders, Philadelphia.
7. Smith, R.L. 1996. Ecology and Field Biology. Harper Collins, New York.

MBC117 Laboratory Course I

1. Determination of air microflora from different habitat using air sampler.
2. Determination of Most Probable Number (MPN) of given water sample.
3. Determination of Dissolve Oxygen (DO) and Biochemical Oxygen Demand (BOD) of given water sample.
4. Determination of rhizospheric effect.
5. Isolation of Nitrogen-fixing bacteria.
6. Industrial visit to understand working and handling procedures used in various microbiological product formations.
7. Mushroom cultivation, spawn production of *Agaricus bisporous.*
8. Single Cell Protein and *Spirulina* production.
9. Determination of growth kinetics of bacteria.
10. Screening of various industrial enzymes from soil bacteria using plate assay (Zone of Hydrolysis).
11. Demonstration of catabolite inhibition using amylase producing bacterial culture.

MBE118 Laboratory Course II

5. Isolation of DNA and plasmid.
6. Restriction digestion of vector and DNA.
7. Ligation of DNA construct and vector.
8. Demonstration of transformation and selection of recombinant clones.
9. Demonstration of inducible enzyme β-galactosidase in *E. coli*.
10. Demonstration of NCBI database.
11. Demonstration of BLAST.
12. Demonstration of identification of bacteria using the 16S rDNA sequence similarity.
13. Demonstration of animated and three dimensional diagrams related to cellular microbiology.
14. Determination of rhizospheric effect.
15. Demonstration of bacterial commensalisms and synergism.
16. Isolation of antibiotic producing microbes from soil sample.
17. Isolation and identification of symbiotic bacteroids of *Rhizobium* sp. from root nodules of leguminous plants.
18. Microscopic observation of root colonization of VAM fungi.
19. Histochemical localization of chemicals in endomycorrhizal symbiosis.

20. Determination of physicochemical parameters of given soil samples.
21. Demonstration of symbiosis and antagonism.
22. 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.
23. To determine the frequency, density and abundance of each species present in community.
24. To calculate relative frequency and relative density of each species in a given area.
25. To calculate mean basal cover and total basal cover of each species in a given area.
26. To compute the relative dominance and IVI (Importance Value Index) of each species in a given area.
27. To calculate the Alpha ($\propto$), Beta (β) and total diversity of given community.
28. To calculate water holding capacity of three samples of various soil types and to find the percolation percentage of water in the given soil.
29. To find out the bulk density and porosity of different soil types
30. To observe the buffering property of the soils.

SEMESTER IV

MBC119 Microbial Diversity including Extermophiles

Unit II
Introduction to microbial diversity- Distribution-abundance-ecological niche. Oxidative transformation metals- Sulfur oxidation, iron oxidation, ammonia oxidation and hydrogen oxidation.

Unit II
Non-culturable and culturable bacteria; conventional and molecular methods of studying microbial diversity.

Unit III
Microbial diversity of anoxic ecosystem- methanogens, reduction of carbon monoxide, reduction of iron, sulfur, manganese, nitrate and oxygen- Microbes and metal reduction, bioleaching of ore, metal corrosion. Microbial transformation of carbon, phosphorous, sulfur nitrogen and mercury.

Unit IV
Extrmophiles- acidophiles, alkalophiles, psychrophiles, thermophiles, barophiles and osmophiles. Physiology, molecular adaptation and application. Halophiles-membrane variation, electron transport.

Unit V
Subterranean microbes- ground water contamination and microbial transformations. Bioaugmentation, biomagnification, bioaccumulation and bioremediation. Catabolic pathway of recalcitrant molecule, degradation and mineralization.

Suggested Reading:

1. Johri B.N. 2000. Extremophiles. Springer Verlag, New York.
2. Colwd, D. 1999. Microbial Diversity. Academic Press.
3. Dubey, R.C. & D.K. Maheshwari. A text Book of Microbiology. S. Chand & Co.

MBC120 Biostatics & Computer Application

Unit I
Introduction: definition of biostatistics, population and universe, the sample and population, statistical inference, parameter and statistics. Interval Data: Construction of histogram, interpretation of histogram, normal distribution, the mean, mode. Median and standard deviation, representing the normal curve, uncertainties in estimation of mean, comparison of means and variance.

Unit II

Proportion Data: Examples of proportion data (MPN, sterlity testing of medicines, animal toxicity, therapeutic trial of drugs and vaccines, animal toxicity, infection and immunization studies) statistical treatment to proportion data. Chi-square test, student's test and f-distributions (derivations not required) their properties and uses. Concept of standard error, goodness of fit. Count Data: Examples of count data (Bacterial cell count, radioactivity count, colony and plaque counts), statistical treatment to count data: Poison distribution, standard error, confidence limits of counts.

Unit III

Measures of dispersion: Range, quartile deviation, mean deviation, standard deviation. Coefficient of variation, skewness and kurtosis. Probability: Random experiment, events, sample space, mutually exclusive events, independent and dependent events. Various definitions of probability, addition and multiplication theorems of probability (only statement), Random variables (discrete and continuous). Probability density functions and its properties.

Unit IV

Analysis of variance: One- way and two-way classifications with single observation per cell. Correlation and regression and line fitting through graph points; standard curves; correlation, linear regression (fitting of best line through a series of points) MLR, Multiple collinearity. Standard curves and interpolation of unknown Y-values.

Unit V

Computer Basics, Operating Systems, Window and Unix. Hardware, Software, Disk Operating System, Multimedia Network Concepts. C-programming; object oriented programming. How the internet works: Local Area Network, Wide Area Network. HTML & XML concepts.

Suggested Reading:

1. Bliss, C.I.K. 1977. Statistics in Biology. Vol.I. Mc Graw Hill, New York.
2. Campbell R.C. 1974. Statistics for biologists. Cambridge University Press.
3. Wardlaw, A.C. 1985. Practical Statistics for Experimental Biologists. John Wiley.
4. E Balaguru Swamy. Programming in C.
5. J. Liberty. C^{++} from scratch.
6. How Computer Work. 2000. Ron White. Techmedia.
7. How Internet Work. 2000. Preston Gralla. Techmedia.

MBC121 Laboratory Course I

1. Isolation of extremophilic microbes from different habitats.
2. Cultivation of anaerobic bacteria.
3. Enrichment culture technique for isolation of xenobiotic compound degrading bacteria.
4. Calculation of mean, median and mode of given data.
5. Calculation of chi-square and t-test of given data.
6. Calculation of ANOVA of given data.
7. Basic handling and various applications of computer software.

HNB Garhwal University, Srinagar-Garhwal, Uttarakhand

SYLLABUS

B. Sc. Microbiology Course (2009 onwards)
(Annual System)

MARK-SCHEME

Class	Paper	Marks Distribution		Total Marks
		Theory	Practical	
I Year	I. Fundamentals of Microbiology	50	50	200
	II. Bacteria, Virus & Protozoa	50		
	III. Algae, Fungi & Plant Pathology	50		
II Year	IV. Microbial Physiology & Biochemistry	50	50	200
	V. Microbial Genetics & Molecular Biology	50		
	VI. Biostatistics, Bioinformatics & Computer application	50		
III Year	VII. Environmental Microbiology	50	50	200
	VIII. Industrial Microbiology	50		
	IX. Medical Microbiology & Immunology	50		

B. Sc. I Year Microbiology

Paper I. General Microbiology

Unit I

History of microbiology, scope and relevance of microbiology, future of microbiology, Outline classification of living organisms: Heckel, Whittaker and Carl Woese systems classification of microbial world; bacteria, cyanobacteria, archaea, actinomycetes, fungi, algae and protozoa.

Unit II

Principle, types and application of microscopes, LAF cabinet, autoclave, oven, colony counter, spectrophotometer, pH meter, anaerobic chamber; Principle, basic apparatus and applications of electrophoresis, thermocyclar (PCR), centrifuge, blotting, Chromatography & its types,

Unit III

Isolation, cultivation and Identification techniques for microorganisms, aerobic and anaerobic cultivation, biochemical methods for identifications, culture media & its type, maintenance & preservation of pure cultures.

Unit IV

Study of Morphology of microbes by staining methods- staining, Simple (Leffer's polychrome methylene blue & negative staining) Gram's staining, Ziel-neelson staining, Fluorochrome staining, Leishman's staining, Giemsa's staining, Special staining methods to demonstrate granules, capsules & spores.

Unit V

Principles and methods of sterilization and disinfection; physical method and disinfection, radiation method, chemical method and fumigation. Antibiotics and their mechanisms of action on microbes.

Suggested Readings:

9. Dubey, R.C. & D.K. Maheshwari. A text Book of Microbiology. S. Chand & Co.
10. Pelczar, M.J., E.C.S. Chan & N.R. Kreig. Microbiology. Tata McGraw Hill.
11. Prescott, L.J., J.P.M. Harley & A.D. Klein. Microbiology. Tata McGraw Hill.
12. Sharma B.K. Instrumental Methods of Chemical Analysis. S. Chand & Co.
13. Wilson and Walker. Biochemistry and Molecular Biology. Cambridge.

Paper II. Bacteria, Virus & Protozoa

Unit I

Microbial diversity and evolution, classification of microorganisms- Haeckel's three kingdom concept, Whittaker's five kingdom concept. Modern trends of bacterial taxonomy, Bergey's system of bacterial classification.

Unit II

Morphology and ultra structure of bacteria; structure, properties and function of cell wall, cell membranes, flagella, cilia, pili, gas vesicles, chromosomes, carboxysomes, magnetosomes and phycobilisomes, nucleoid.

Unit III

General Virology: Brief outline of discovery of viruses, nomenclature and classification of viruses. Morphology and ultrastructure, capsids and their arrangements, types of envelopes and their compositions. Viral genome, their types and structures. Virus related organisms (viroids, virusoids and prions). Cynophages: morphology, growth cycle. Mycoviruses

Unit IV

Bacterial viruses: Bacteriophage structural organization, life cycle, one step growth curve, transcription, DNA replication, eclipse phase, phage production, burst size, lysogenic size, bacteriophage typing, application in bacterial genetics, brief details on M13, Mu, T4, Lembda.

Unit V

The origion of protozoa. Flagellate protozoa: the Mastigophora, ameboid protozoa: the Rhizopoda, ciliate protozoa: the Ciliophora**.** Protozoal disease: malaria, Giardiasis, Trichomoniasis**,** Toxoplasmosis, Pneumocystis pneumonia and disease caused by Leishmania, Trypanosomes.

Suggested Readings:

1. Dubey, R.C. & D.K. Maheshwari. A text Book of Microbiology. S. Chand & Co. New Delhi.
2. Pelczar, M.J., E.C.S. Chan & N.R. Kreig. Microbiology. Tata Mc Graw Hill.
3. Prescott, L.J., J.P.M. Harley & A.D. Klein. Microbiology. Tata McGraw Hill.

Paper III. Algae, Fungi & Plant Pathology

Unit 1

Algae: General account of habitat, cell structure, pigments, flagellum, reserve food. Various systems of classification. Conflicts of taxonomic position of cyanobacteria. Algal growth and reproduction.

Unit II

Cultivation of algae in laboratory. Nittrogen fixation. Biological and economic aspects of algae, algal biotechnology. Fossil records of algae. Algal blooms and eutropication.

Unit III

Fungi: Historical introduction to mycology. Habitat, fungal structure and thallus organization, wall structure, hyphal growth, sexual and asexual reproductive structures, various systems of classification.

Unit IV

Nutrition and reproduction in fungi, Mycorrhiza, Lichens, Heterothallism, sex hormones in fungi. Evolutionary tendencies in lower fungi. Economic importance. Fungal diseases.

Unit V

Concept of plant disease; signs and symptoms associated with microbial plant pathogens. Microbial enzymes, toxins, growth regulators & suppressors of plant defenses in plant diseases, effects of pathogens on plant physiology, concepts of passive and active resistance mechanisms in plants**.** Concepts of monocyclic & polycyclic diseases, physical, chemical and biological control, integrated eco-friendly approach of plant disease control.

Suggested Readings:

7. Mehrotra, R.S. & K.R. Aneja. 1990. An introduction to mycology. New Age International Publisher.
8. Charlie, M., & S.C. Watkinson. The Fungi. Academic Press.
9. Alexopoulos C.J. & Mims C.J. Mycology. Willey.
10. Sharma, O.P. Algae. Pragati Prakashan.
11. Vashishth B.R. Algae. S. Chand & Co.

Practical recommended for B. Sc. I Year (Microbiology) course

1. Principle operation and study of various components of Microscopes.
2. Calibration of ocular microscope for different objectives of microscope.
3. Measurement of micro-organism by the use of an ocular micrometer.
4. Demonstration of pH meter.
5. To prepare buffer solution from buffer tablets as well as from reagents.
6. Sterilization techniques for glassware and culture media.
7. Preparation of culture plates and tubes (liquid broth, potato dextrose agar medium, agar deep tubes, agar slants)

8. Demonstration of techniques for isolation of pure culture of bacteria from water and soil samples.
9. Demonstration of techniques for isolation of pure culture of fungi from water and soil samples.
10. Isolation of actinomycetes from soil.
11. Purification of micro-organism by streak plate method.
12. Microbial growth measurement by serial dilution method and standard plate count.
13. Identification of bacteria by simple staining, gram staining, negative staining.
14. Quantification of bacteriophage by plaque assay techniques.
15. Demonstration of preservation techniques for microorganisms.
16. Counting of spores/ cells of microbes.
17. Study of important cyanobacteria and algae, their morphological features, identification and classification.
18. Studies including morphology, symptomatology and identification of plant pathogens (Bacterial, viral, fungal and protozoans)

B. Sc. II Year Microbiology

Paper IV. Microbial Physiology & Biochemistry

Unit I

Structural feature and functions of biological macromolecules; proteins, lipids, carbohydrates, nucleic acids. Prokaryotic genetic material, RNA as genetic material.

Unit II

Enzymes as biocatalyst, enzymes classification, properties. enzyme kinetics: Michaelis-Menton equation for simple enzymes, Effects of pH and temperature on enzyme action, enzyme inhibition Electron carriers, artificial electron donors, inhibitors, uncouplers, energy bond and phosphorylation.

Unit III

Microbial metabolism: anabolism and catabolism, energy production in aerobic, anaerobic process and photosynthesis, chemiosmotic hypothesis of ATP synthesis. Bacterial electron transport chain. Autotrophy, heterotrophy, chemolithotrophy, fermentation. Transport of nutrients by active and passive transport.

Unit IV

Respiratory metabolism- Glycolysis, EMP Pathway, ED pathway, Glyoxallate pathway, Kreb's cycle- oxidative and substrate level phosphorylation. Reverse TCA cycle- Gluconeogenesis, fermentation and carbohydrates- homo and heterolactic fermentations.

Unit V

Assimilation of nitrogen- dinitrogen, nitrate nitrogen, ammonia assimilation, synthesis of major amino acids, synthesis of polysaccharides- peptidoglycan, bipolymers as cell components.

Suggested Readings:

1. Stryer. 2001. Biochemistry. 5^{th} ed. WH Freeman.
2. Nelson & Cox. 2002. Lehinenger Principles of Biochemistry. Worth Publ.
3. Harpers Biochemistry. 1999. Mc Graw Hill.
4. Caldwell, DR. 1995. Microbial Physiology & Metabolism. Brown Publishers.
5. Moat & Foster. Microbial Physiology. 1999. Wiley.

Paper V. Microbial Genetics & Molecular Biology

Unit I

Nucleic acid s as genetic information carrier: Experimental evidence. DNA tructure, Historical aspects and current concepts. DNA replication, General principles, various modes of replication.

Unit II

Gene as a unit mutation and recombination. Molecular nature of mutations. Mutagens. Spontaneous mutation origin. DNA damage and and repair: type of DNA damage (deamination, oxidative damage, alkylation, pyridine dimers). Repair mechanisms- methyl directed mismatch repair, very short patch repair, nucleotide excision repair, base excision repair, recombination repair, SOS system.

Unit III

Gene expression and protein synthesis: Structural features of RNA (rRNA, tRNA & mRNA) and relation of function. Transcription: general principles, type of RNA polymerases, steps; initiation, elongation and termination. Inhibitors of RNA synthesis. Polycistronic and monocystronic RNAs. Basic features of genetic code. Protein synthesis and its step; initiation, elongation and termination. Inhibitors of protein synthesis.

Unit IV

Gene transfer mechanisms- transformation, transduction, conjugation and transfection, mechanism and applications. Plasmids: F factor description and their use in genetic analyss. Bacteriophages: Lytic phages- T4. Lysogenic phage- lambda ϕX174: uses in microbial genetics.

Unit V

Gene conversion, site specific recombination, transposable elements, nomenclature, insertation sequences, transposons.

Suggested Readings:

7. Gardner, Simmons & Snustad. Principles of Genetics. John Willy & Sons.
8. Friefelder, Jones & Bartlett. Microbial Genetics. Narosa-Panima.
9. Glick, B.R. & J.J. Pasternak. Molecular Biotechnology. Panima.
10. Tamrin. Principles of Genetics. Tata McGraw Hill.

Paper VI. Biostatistics, Bioinformatics & Computer application

Unit I

Introduction: definition of statistics, population and universe, the sample and population, statistical inference, parameter and statistics. Measures of central tendency: Mean median, mode and their relationship, standard deviation, representing the normal curve, Chi-square test, student's t test, goodness of fit.

Unit II

Probability: Random experiment, events, sample space, mutually exclusive events, independent and dependent events. Various definitions of probability, addition and multiplication theorems of probability (only statement), Random variables (discrete and continuous). Probability density functions and its properties. Some probability distributions such as binomial, Poisson and normal (Basic idea about these distributions) and their applications.

Unit III

Analysis of variance: Analysis of co-variance; Introduction, procedure and tests, multiple comparisons. Correlation and regression and line fitting through graph points; standard curves; correlation, linear regression (fitting of best line through a series of points), Multiple colinearity. Standard curves and interpolation of unknown Y-values.

Unit IV

What is bioinformatics, Importance of bioinformatics, Biological database; primary and secondary database. DNA sequence database. DNA sequence analysis, pair wise alignment, multiple sequence alignment.

Unit V

Computer Basics: Component of computer system. Memory: primary and secondary. CPU, Operating system: definition, importance, Disc Operating System. Network: Types of network, Local Area Network (LAN), Wide Area Network (WAN), Metropolitan Air Network (MAN). Internet: basic idea.

Suggested Readings:

1. Ron White. How Computer Work. 2000. Techmedia.
2. Preston Gralla. How Internet Work. 2000. Techmedia.
3. Bliss, C.I.K. 1977. Statistics in Biology. Vol.I. Mc Graw Hill, New York.
4. Campbell R.C. 1974. Statistics for biologists. Cambridge University Press.
5. Wardlaw, A.C. 1985. Practical Statistics for Experimental Biologists. John Wiley & Sons.
6. Glover. An Introduction Biostatistics.
7. Mishra & Mishra. An Introduction Biostatistics. Kalyani Publication.

Practical recommended for B. Sc. II Year (Microbiology) course

1. Analysis of carbohydrates in given samples.
2. Estimation of protein in given samples.
3. Analysis and estimation of lipid in given samples.
4. Blood group and Rh factor determination.
5. Demonstration of WIDAL test.
6. Isolation of normal micro flora of skin and mouth teeth crevices.
7. Testing of antimicrobial activity of the skin on bacteria.
8. Microscopic observation of infected tissues for pathogenic fungi and bacteria in plants and animal.
9. Determination of quality of milk samples by Methylene Blue Reduction test.
10. Microbiological examination of food samples.
11. Microscopic observation of starter culture for curd.
12. Observation of eutrophication in stagnant water and its microscopic study.
13. Microscopic observation of root nodules of leguminous plants for nitrogen fixing bacteria.
14. Visit of waste water treatment plant.

B. Sc. III Year Microbiology

Paper VII. Environmental Microbiology

Unit I

Air Pollution: Sources, types, effect of pollutants, control measures brief account of air born transmission of microbes; viruses, bacteria and fungi, their diseases and preventive measures. Aeroallergy and aeroallergens. assessment of air quality.

Unit II

Aquatic microbiology: water ecosystem and its type, marine microorganisms and their importance, eutrophication, brief account of major water born diseases and their control measures.

Unit III

Soil microbiology: classification of soil, physical and chemical characteristics, micro flora of various soil types, brief account of microbial interactions, symbiosis-mutulism, commensalisms, competition, amensalism, synergism, parasitism, predation.

Unit IV

Biogeochemical cycles and the microorganisms- carbon, nitrogen, phosphorous and sulfur; biofertilizer; Vesicular Arbuscular Micorrhizae (VAM); ecto, endo, ectendo mycorrhizae.

Unit V

Water treatment- wastes, types, solid and liquid wastes characterization, primary, secondary, tertiary solid waste treatment, Bioaccumulation, Bioremediation, Bioleaching of copper and uranium, Environmental impact assessment: Introduction, Assessment & Control.

Suggested Readings:

1. Atlas & Bartha. Microbial Ecology. 2007. Pearson Education.
2. Paul & Clark. Soil Microbiology & Biochemistry. Academic Press.
3. Jogdand S.N. Environmental Biotechnology. Himalaya Publishing House.
4. Powar & Daginawala. Microbiology. Himalaya Publishing House.
5. Dubey R.C. & D.K. Maheshwari. A text Book of Microbiology. S. Chand & Co.

Paper VIII. Industrial Microbiology

Unit I

Isolation of industrially important microbial strains, strain improvement, preservation and maintenance of industrial microbes, scale-up. Criteria used for selection of microorganisms for fermentation. Growth kinetics of industrially important microorganisms.

Unit II

Fermentation processes: Batch, fed-batch and continuous fermentations; solid state and submerged fermentations. Components in a typical bioreactor and types. Maintenance of pH, temperature, dissolved oxygen and aeration.

Unit III

Substrate for industrial fermentation: Molasses, corn steep liquor, sulfite waste liquor, whey, yeast extract. Detection and assay of fermentation product. Down Stream Processing, immobilization & its applications. Antifoams.

Unit IV

Microbial production of industrial products; citric acid, ethanol, acetone, penicillin, streptomycin, vitamin B12, riboflavin, amylase, single cell protein. Biofertilizers, bioinsecticides.

Unit V

Food as a substrate for micro-organisms, microbial spoilage of different food-stuffs, principles and methods of food preservation. Microbiology of milk, dairy products and fermented foods. Single cell protein. Food-borne diseases. Mycotoxins with reference to aflatoxins.

Suggested Readings:

1. Crueger & Crueger. Biotechnology. Panima Publ.
2. Adams M.R. & M.O. Moss.1995. Food Microbiology. Cambridge.
3. Frazier W.C. & D.C. Westhoff. 1988. Food Microbiology. Tata McGraw Hill.
4. Stanbuty, P.F., & S.J. Hall. 1995. Principles of Fermentation Technology. Pergamon Press.

Paper IX. Medical Microbiology & Immunology

Unit I

Historical background of medical microbiology, Classification of medically important microorganisms. Disease cycle, transmission of pathogen and its routes. Infection and its type. Host-parasite relationships, pathogenicity and virulence in relation with bacteria, virus fungi and parasites

Unit II

Silent features of the diseases caused bacteria: *Clostridium, Bacillus, Staphylococcus, Streptococcus, E.coli, Klebsiella, Salmonella, Pseudomonas, Vibrio, Neisseria*, Mycobacteria. Viral disease- Hepatitis, HIV, dengue fever, small pox, polio. Protozoan disease- Malaria & Amoebiasis.

Unit III

Protein toxins- types and disease, early diagnosis and detection of disease by serological methods- RIA, ELISA, complement fixation, agglutination; chemotherapy- types and action mechanisms of antimicrobials; antimicrobial assay and drug resistance; vaccines; interferon.

Unit IV

History of immunology, composition and functions of cells and organs involved in immune system; Immune response and its type- innate (non specific), acquired (cell mediated and humoral) immunity.

Unit V

Antigens- structure and properties, Immunoglobulin- structures, properties & functions, Antigen- antibody reactions-ELISA, RIA, Agglutination & precipitate; Complements- Structure and functions; Major Histocompatibility Complex (MHC): Structure and functions; Autoimmunity and Hypersensitivity reactions**.**

Suggested Readings:

7. Ananthanarayan & Panicker. 1997. Text Book of Microbiology. Oriental Longman.
8. Dubey R.C. & D.K. Maheshwari. A text Book of Microbiology. S. Chand & Co.
9. Prescott L.J., J.P.M. Harley & A.D. Klein. Microbiology. Tata McGraw Hill.
10. Kuby J. 1994. Immunology. W.H. Freemen & Company, New York.
11. Baron E.J., Peterson L.R., Finegold, S.M. Mosby. 1990. Bailey & Scott's Diagnostic Microbiology.
6. Chakrabarty. Immunology & Immunotechnology. Oxford.

Practical recommended for B. Sc. III Year (Microbiology) course

1. Two to three different exercises in biostatics.
2. Two to three different exercises for demonstration of hardware, software and internet.
3. Isolation of crude bacterial DNA.

4. Demonstration of electrophoresis.
5. Demonstration of PCR.
6. Demonstration of lethal effect of UV (to explain the UV induced mutation).
7. Demonstration of Indole production by bacterial culture.
8. Demonstration of Methyl Red and Voges-Proskauer test.
9. Demonstration of Citrate utilization test.
10. Demonstration of Catalase test.
11. Demonstration of amylase production by bacterial cultures.

B.Sc. Botany Syllabus 2006 Onwards

B. Sc. I Year

Paper- I Fungi, Microbiology and Elementary Plant Pathology

Unit I

1. Brief history and salient features of fungi.
2. Outlines of classification of Alexopoulos and salient features of the important group.
3. Habit, habitat, structure and methods of reproduction of fungi based on the following representatives. *Stemonitis, Synchytrium, Saprolegnia, Mucor, Penicillium, Phyllactinia, Eurotium, Sacchromyces, Morchella, Puccinia, Agaricus and Alternaria*.

Unit - 2

1. Distribution and classification of the microorganisms.
2. Elementary principles of isolation and purification of the microorganisms. Identification and differentiation of bacteria on the basis of morphology and stains (Negative staining, Gram's stain and Acid Fast).
3. Decomposition of organic matter in soil and the role of the microorganisms in carbon and nitrogen cycles in nature,

Unit - 3

1. Fine structure of bacteria, their classification, nutrition and reproduction. Economic importance of bacteria.
2. Viruses: Nature, structure transmission, multiplication and economic importance. Bacteriophages- a brief idea.
3. Mycoplasma: a general account.

Unit -4

1. Lichens: Occurrence, physiology (symbiotic relationship) and general structure.
2. Nutrition and reproduction in lichens with special reference to Parmella.
3. Economic importance of Lichens.

Unit - 5

1. General symptoms of plant diseases.
2. General principles of infection and resistance.
3. General methods of chemical and biological control of the plant diseases.
4. The symptoms, morphology of the causal organism, disease cycle and control measures of the following disease: White rust of Crucifers, Late blight of potato, Loose smut of wheat, Black rust of wheat, and Wart disease of potato, Red rot of sugarcane.

Paper- II Algae and Bryophytes

Unit-1

1. General characteristic of the group (Algae) and its position in Plant Kingdom.
2. Classification of algae, basic outlines of Fritsch's and Smith's classification.
3. Elementary knowledge of organization of thallus in algae.

Unit-2

1. Occurrence, structure of thallus and mode of reproduction in the following genera:
   Chlamydomonals, Volvox, Hydrodictyon, Cladophora, Oedogonium, Vaucheria and Chara.
2. General account of the Bacillariophyceae.
3. Ecology of Algae – A brief idea of fresh water, marine and terrestrial algae, phytoplanktons, epiphytic, parasitic and symbiotic algae.

Unit-3

1. Occurrence, structure and mode of reproduction of the following genera: Sargassum, Ectocarpus, Batrachospermum, Polsiphonia.
2. Cynobacteria: A general account, Nostoc and Spirulina.
3. Economic importance of Algae as food and fodder in agriculture, industry and in public health.

Unit-4

1. Outlines basic principles of classification of the Bryophytes in accordance with the International Code of Botanical Nomenclature.
2. Comparative account of the gross morphology, anatomy, vegetative and sexual reproduction, development and structure of the sporophytes and mechanism of spore dispersal based on Riccia and Marchantia.
3. Habitat, distribution and economic importance of Bryophytes.

Unit-5

1. Comparative account of the gross morphology, anatomy of the gametophyte, vegetative and sexual reproduction, development and structure of the sporophytes and mechanism of spore dispersal in Anthoceros.
2. General account of the jungermenniales (Pellia and Porella) and Moses (Funaria and Pogonatum).
3. A brief account of the alternation generationin bryophytes.

Paper- III Pteridophytes, Gymnosperms and Elementary Palaeobotany

Unit-1

1. General characters of pteridophytes and classification as proposed by Pichi-Sermoli.
2. A comparative study Rhynia, selaginella, Lycopodium, Equisetum, Adiantum and marsilea on the basis of following features.
3. Morphology and anatomy of the vegetative plant body and spore production organs (strobilus, sporocarp, sporophyll, sporangium and spores), sexual reproduction, male and female gametophytes, fertilization.

Unit-2

1. A brief account of Telome theory, Stelar system and its evolution.
2. Heterospory and seed habit in Pteridophytes.
3. Apogamy, agamospory and apospory in ferns.

Unit-3

1. Outlines classification as proposed by D.D. Pant and distinguishing features of Gymnosperms.
2. Comparative account of the structure, life history, and evolutionary trends based on the following examples:
   Cycas, Pinus and Ephedra.
3. General anatomy-types of wood thickening, trachieds, medullary rays, pitting and resin canals, mesarch and pseudomesarch, foliar bundles and stomata in three types.

Unite-4

1. Distribution of Gymnosperms in India.
2. Economic importance of the Gymnosperms

Unite- 5

1. Fossils: Process of fossilization and types of fossils.
2. A general idea about Geological era.
3. Living fossils.

B. Sc. II Year

Paper I Taxonomy of Angiosperms

Unite-1

1. Angiosperms origin and evolution. Some examples of primitive angiosperms. Angiosperm taxonomy- fundamental components.
2. Historical development in plant taxonomy in pre-Linnaeus and post-Linnaeus periods.
3. Comparison and evolution of the systems of classification as proposed by Linnaeus, Bentham and Hooker and Huchinson.

Unit-2

1. Nomenclature: International Code of Botanical Nomenclature (ICBN), history, scientific naming of plants, priority, types, validity, nomina conservanda.
2. Collection and preservation techniques of specimens for herbarium and museum.
3. Botanical gardens and Herbaria. A brief idea of Botanical Survey on India BSI).

Unit-3

1. Taxonomy, important distinguishing characters, classification and economic importance of the following families:
   Dicotyledonae:
   Polypetalae: Ranunculaceae, Papaveraceae, Caryophyllaceae, Malvaceae, Meliaceae, Rutaceae, Fabaceae, Rosaceae, Cucurbitaceae, Apiaceae.

Unit-4

1. Gamopetalae: Rubiaceae, Solanaceae, Convolvulaceae, Apocynaceae, Asclepiadaceae, Acanthaceae and Lamiaceae.
2. Monochlamydae: Euphorbiaceae, Moraceae and Polygonaceae.
3. Monocotyledonae: Orchidaceae, Liliaceae and Poaceae.

Unit-5

1. Biodiversity: Basic concept, biodiversity at global and national level, causes of loss of biodiversity.
2. Biodiversity conservation Action plan: in situ conservation, gene bank, introductory account of Biosphere Reserves, National Parks and Sanctuaries.
3. Floristic Regions of India, flora and vegetation, Indian flora and endemism, characteristics of West Himalayan flora with reference to Uttarakhand Himalaya.

Paper II Anatomy, Embryology and Elementary Morphogenesis

Unit-1

1. The techniques for the study of plany anatomy.
2. Meristems-Primary and secondary meristems, characteristics and functions. Various types of permanent tissues.
3. Root-stem transistion.

Unit-2

1. Secretory structure.
2. Origin, structure and function of vascular cambium including anomalous behavior with special reference to the following taxa: Bougainvillea, Salvadora, Nyctanthes, Dracaena, Beta, Ficus, Orchids and Tinospora.
3. Structure of xylem and phloem including the electron microscopic view, cork cambium, its activity and products.

Unit-3

1. Structure of anther, micro sporogenesis and development of male gametophytes in angiosperms.
2. Structure of ovule, mega sporogenesis and development of the female gametophytes with reference to the Polhtonum type, comparison with the bisporic and tetrasporic types.
3. Pollination, fertilization and life history of a typical angiosperm.

Unit-4

1. Endosperm and embryo development with special reference to the onagrad type.
2. Polyembryony and apomixis.
3. Seed germination and dormancy, elementary plant movements.

Unit-5

1. Basic body plan of a flowering plant-molecular type of growth.
2. Diversity in plant form in annuals, biennials, and perennials, development of tree habit in higher plants.
3. Plant growth regulators, Auxins, Gibberellins, Cytokinins and Abscissic acid.
4. Physiology of flowering – Photoperiodism and vernalization.

Paper III Ecology and Biostatistics

Unit-1

1. Definition and scope of ecology.

2. Ecosystem: type, abiotic and biotic components, food chain, food-web and ecological pyramids, specialized ecosystems, Homoeostasis-fluctuation in ecosystem.
3. Energy flow and ecological energetic, Lindeman's concept of energy flow.
4. Productivity, type, measurement of primary productivity; turn over, food chain, food web.

Unit-2

1. Biogeochemical cycles: A brief discussion of concept by giving examples of carbon, nitrogen and phosphorus cycles.
2. Ecological niche, Bio-indicators and their role in environmental monitoring, guide.
3. Population ecology: Definition, population characters, survivorship curves, population age distribution, basic concept of growth rate, growth forms and growth curves; carrying capacity, population fluctuation.
4. Community ecology: Community characteristics, ecological succession, structure, composition and trophic organization, quantitative, qualitative and synthetic features, life forms and biological spectrum.

Unit-3

1. Applied ecology: Soil erosion and conservation, conservation and management of some Natural Resources: Forest and rangeland management.
2. Pollution of air, water and soil, environmental toxicology, noise incidence; Thermal and radioactive pollution; Prevention and control of pollution.
3. Global warming, desertification and ozone depletion.
4. Biogeographical regions of India; Vegetation types in Uttarakhand.

Unit-4

1. Aerial photo-interpretation and remote sensing- an outline with special reference to the types of aerial photography and maps.
2. Physical basis for remote sensing; aerial and space platforms.
3. Application of remote sensing in ecology.

Unit-5

1. Methods of representation of statistical data diagrams.
2. Measurements of central tendencies- mean, median, mode, harmonic mean and geometric mean.
3. Measures of dispersion-range, mean deviation and standard deviation, standard error.
4. Coefficient of correlation.
5. Test of significance- chi square test.

B. Sc. III Year

Paper-1 Cytogenetics,molecular biology And Biotechnology

Unit-1

1 Structure and function of nucleus: Ultra Structure, nuclear membrane; Nucleous Structre and function of other organelles: Golgi, ER, peroxisomes, Vacuoles, The

Cell envelopes: envelopes: plasma membrane, bilayer lipid Structure,functions of Cell.

2 Cell division : mitosis, meiosis, comparison.

3 Chromosome organization: morphology, centromere and telomere, chromosome alteration in chromosome numbers, anenploidy, polyploidy, sex chromosomes.

4 Extranuclear genome: Presence and function of mitrochondial and plastid DNA, plasmids.

Unit-II

1. Genetic Inheritance: Mendelism: Law of segregation and independent assortment, incomplete dominance.
2. Interaction assortment, incomplete linkage, lindage groups; Crossing over.
3. Sex linked inheritance; Determination of sex.
4. Genetic variation: Mutations, transposable genetic elements, DNA damage and repair.

Unit- III

1. DNA the genetic material: DNA structure, replication DNA –DNA.
2. RNA structure and type.
3. Gene concept: classical and modern concept of gene, operon concept.

Unit- IV

1. Protein structure: 1D, 2D and 3D Structure.
2. Genetic code and protein synthesis.
3. Regulation of gene expression in prokaryotes and eukaryotes.

Unit- V

1. Genetic engineering: Tool and techniques of DNA technology, cloning vectors, genome and cDNA libraries,transposable elements, techniques of gene mappiong and chromosome walking.
2. Biotechnology: Functional definition, basic concept of tissue culture, storage of germ plasm (cryopreservation), differentiation and morphogenesis, biology of agrobacterium, vectors for gene delivry and marker.
3. A brief account of industrial biotechnology (fermentation and alcohol production), Agriculture biotechnology (biofertilizers and biopesticides) and Nutritional biotechnology (Mycotoxin and health hazards, control of mycotoxin production, single cell protein).
4. Elementary idea of (i) Gene bank, (ii)Nif gene, (iii) Nod gene, (iv) Totipotency (v)Antibiotics and (vi)Mycoprotein.

Paper-II Phisiology and Biochemistry

Unit-1

1. Cell Physiology, diffusion, permeability, plasmolysis, imbibition, water potential and osmotic potential.
2. Types of soil water, water holding capacity, water requirement, wilting coefficient.
3. Active and passive absorption, anatomical features of xylem in relation to path of water transport ascent of sap.

Unit-2

1. Loss of water from plants, transpiration, factors affecting transpiration, guttation, anatomy of the leaf with reference to the loss of water.
2. Structure of stomata, mechanism of stomatal movement and diffusion capacity of the stomata.
3. Mechanism of absorption of mineral salts.
4. Translocation of solutes, theories and mechanism of translocation, anatomical features of the phloem tissue with reference to the translocation of solutes.

Unit-3

1. Elementary knowledge of the macro and micronutrients.
2. Symptoms of mineral deficiency, techniques of water and send culture.
3. Nitrogen cycle and nitrogen fixation, Importance of nitrate reductase and its regulation, Ammonium assimilation.

Unit-4

1. Photosynthesis, historical background and importance of the process, role of primary pigments, Concepts of two photosystems, Z-scheme, Photophosphorylation Calvin cycle; Factors affecting photosynthesis, chemosynthesis.
2. Respiration, glycolysis, Kreb's cycle, Electron transport mechanism (Chemiosmotic theory), ATP- the biological energy currency, Redox potential, oxidative phosphorylation, pentose phosphate pathway, CAM plants; Factor affecting respiration, fermentation.

Unit-5

1. Types and strength of solutions, acid base and salts, pH, buffer solutions and their importance, redox potential.
2. Enzyme action
3. Kinetics, active sites, Michaelis-Menton constant, classification of enzymes, factors affecting the enzymes activity, coenzymes and cofactors.
4. Carbohydrates- classification, properties, structures and biological role.
5. Proteins and amino acids- classification, Structure and chemical bonds in protein Structure and properties.
6. Lipids: structures and functions, fatty acid biosynthesis, B-oxidation, saturated and unsaturated fatty acids, storage and mobalization of fatty acids.

Paper-III Economic Botany and Plant breeding

Unit-1

1. Importance of plants to man-kind.
2. Origin of cultivated plants, monophyletic and polyphylaticorigin; centre of origin of some important crop plants.

Unit-2

1. Origion, history, botanical features and cultivation of cereals- wheat, paddy, maize, bajra.
2. Legumes- An introduction to the economically important legumes.
3. Oil- castor oil, linseed oil, mustard oil and mint oil.

Unit-3

1. General account of fruit (Apple, banana, citrus, litchi and mango) and vegetable (root, stem, leaf and fruit vegetable) plants.
2. fibres(coir, cotton, flex, hemp) and medicinal (Aconitum, Atropa, Cinchona, Ephedra and Rauwolfia) plants.
3. Common timber yielding plants (Chir, Deodar, Sal, Shisham and Teak) of western Himalaya.

Unit-4

1. Plant breeding: Aims and objectives, basic technique of plant breeding.
2. Crop improvement method- plant introduction, selection, acclimatization, hybridization. Vegetative propagation and grafting.
3. Mutational breeding and breeding of disease resistance

Unit-5

1. Improved seeds- production, multiplication and distribution.
2. Maintenance and seed testing.
3. National Seed Corporation and seed testing laboratories.