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)

<table>
<thead>
<tr>
<th>Code</th>
<th>Paper</th>
<th>Credits*</th>
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<tbody>
<tr>
<td>BSC101</td>
<td>I. Mycology and Microbiology</td>
<td>03</td>
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<tr>
<td>BSC102</td>
<td>II. Phycology and Bryology</td>
<td>03</td>
</tr>
<tr>
<td>BSC103</td>
<td>III. Pteridology, Gymnosperm and Palaeobotany</td>
<td>03</td>
</tr>
<tr>
<td>BSC104</td>
<td>IV. Taxonomy and Diversity of Flowering Plants</td>
<td>03</td>
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<tr>
<td>BSC105</td>
<td>V. Laboratory Course I**</td>
<td>03</td>
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<tr>
<td>BSC106</td>
<td>VI. Laboratory Course II</td>
<td>03</td>
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Core Credits= 18

M. Sc. Semester II (December to April)

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<thead>
<tr>
<th>Code</th>
<th>Paper</th>
<th>Credits</th>
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<tbody>
<tr>
<td>BSC107</td>
<td>VII. Plant Development and Reproductive Biology</td>
<td>03</td>
</tr>
<tr>
<td>BSC108</td>
<td>VIII. Resource Utilization, IPR and Ethnobotany</td>
<td>03</td>
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<tr>
<td>BSC109</td>
<td>IX. Cytogenetics and Molecular Biology</td>
<td>03</td>
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<tr>
<td>BSC110</td>
<td>X. Plant Breeding and Biostatistics</td>
<td>03</td>
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<tr>
<td>BSC111</td>
<td>XI. Laboratory Course I</td>
<td>03</td>
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<tr>
<td>BSC112</td>
<td>XII. Laboratory Course II</td>
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Core Credits= 18 with additional 03 Credits of Self Study.

M. Sc. Semester III (July to November)

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

Core Credits 09 + Elective Credits 09; Total Credits= 18 + 03 credits of self study.
M. Sc. Semester IV (December to April)

<table>
<thead>
<tr>
<th>Code</th>
<th>Paper</th>
<th>Credit</th>
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<tbody>
<tr>
<td>BSC119</td>
<td>XIX. Conservation Biology</td>
<td>03</td>
</tr>
<tr>
<td>BSC120</td>
<td>XX. Biotechnology and Genetic Engineering</td>
<td>03</td>
</tr>
<tr>
<td>BSC121</td>
<td>XXI. Laboratory Course I</td>
<td>03</td>
</tr>
<tr>
<td>BSE122</td>
<td>XXII. Dissertation</td>
<td>09</td>
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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.
** 03 hours 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.
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, sesame 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:

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.
13. Fossil bryophytes, physiology and morphogenesis.

SUGGESTED READINGS:

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. Psilopsis: Psilophytales (Psilophyton) and Psilotales (Psilotum).
   b. Lycopsida: Protolepidodendrales (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.
   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:
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.
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:

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

**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.


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


7. Study and identification with suitable preparations of *Ricciocarpus*, *Targionia*, *Cyathodium*, *Plagiochasma*, *Asterella* (*Fimbraria*), *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.

SUGGESTED READINGS:
27. The American Society of Plant Physiologists 1993. The Plant Cell. Special Issue on Reproductive Biology of Plants, Vol. 5 (10), Rockville, Maryland, USA.
1. Plant resources: Concept, status, utilization and concerns.
2. World Centers of Primary Diversity of domesticated plants
3. Origin, evolution, botany, cultivation, cytotaxonomy and uses of (i) Cereals and millets (wheat, paddy, maize), (ii) Legumes (soybean, black gram and cowpeas), (iii) Sugar cane and starches (sugarcane, beetroot, potato, sweet potato, cassava), (iv) Forage and fodder crops.
4. Fiber crops, medicinal and aromatic.
5. Important firewood and timber yielding plants and non-wood forest products (NWFPs) such as bamboos, gums, tannins, dyes, resins, beverages.
7. Ethnobotany: Concept, linkage with other sciences, tools of ethnobotanical studies, world and Indian perspective with special reference to the Himalayas.
9. Plants used as ornamentals and avenue trees.
11. Strategies for conservation: In situ conservation; Protected areas in India- sanctuaries, national parks and biosphere reserves.

SUGGESTED READINGS:
19. Nair, M.N.B. et al. (Eds) 1998. Sustainable Management of Non-Wood forest Products. Faculty of Forestry, Universiti Putra Malaysia. 434004 PM Serdang, Selangor, Malaysia

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.
5. Nucleus: structure, nuclear pores, nucleosome organization.
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.
10. Genetics of prokaryotes and eukaryotic organelles: Mapping the bacteriophage genome, phage phenotypes; genetic recombination of phage; genetic transportation, conjugation and transduction in bacteria, cytoplasmic male sterility.
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:
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
2. Methods of representation of statistical data and measurements of central tendencies.
3. Correlation, regression, curve fitting and ratio of variation.
5. Test of significance, X², ‘t’ and ‘f’ tests.

SUGGESTED READINGS:
Plant Breeding:

Biostatistics:

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.).


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. Restriction digestion of plant DNA, its separation by agarose gel electrophoresis and visualization by ethidium bromide staining.

5. Isolation of RNA and quantitation by spectrophotometric method.


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.
15. To test the goodness of fit and independent assortment using Chi-square method.

Manuals for Laboratory Exercises.

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.
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 C₄ 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.

SUGGESTED READINGS:


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 (CO₂, CH₄, N₂O, CFCs; sources, trends and role); Ozone layer and ozone hole; consequences of climate changes (CO₂ fertilization, global warming, sea level rise, UV radiation).
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 Uttarakhand; 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:

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.
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).
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:


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

Aerial Photography and Photogrammetry (AP&P):
2. Introduction to Photogrammetry, Geometry of Aerial photos, Stereoscopic photography, Measurement of Height, Aerial Triangulation.

Remote Sensing (RS):
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):

Geoinformatics (GIS):
10. Basics of Computer, Hardware and software,

Suggested Readings:

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
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:

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.
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.
10. Water resources, status and conservation in India.
11. Watershed management techniques (vegetation type conversion, water harvesting, reservoir construction, drainage channelization etc).
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:

BSE 115. Paper XV e: PALYNOLOGY AND POLLINATION BIOLOGY

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.
4. Paynotaxonomy: Systematic palynology, identification key and evolutionary trends among pollen grains based on palynotaxonomical works.
5. Aeropalynology with reference to allergy: Aeroallergens, introductory idea of Immune System with special reference to IgE. Study of aircspora, 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.


**SUGGESTED READINGS:**

**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 incompatibility; Types of grafts: Detached scion graftage, Approach graftage, Repair graftage; Scion-rootstock relationship; Aftercare of grafted plants.
6. Techniques of Budding: Rootstock for budding; Time of budding; Types of budding; Micro budding.
7. Layering and its natural modifications: Physiology of regeneration by layering; Procedures in Layering; Management of plants during layering; Plant modifications resulting in natural layering;

8. Micro-propagation: Micro-propagation of plantlets from tissue culture; Types of systems used to regenerate plantlets by micro-propagation Callus, cell and protoplast culture systems.

SUGGESTED READINGS:
BSE 116 Paper XVIa. PLANT HEALTH MANAGEMENT

2. Seed Pathology: Seed borne fungi. Disease transmitted through seeds. Biodeterioration of seed in storage. Control of seed borne fungi.
   Plantation disease: Plantation disease of Chir pine, Eucalyptus, Sal, Teak, Shisam, Populus, Acacia (Catechu).
   Introduction and various forms of Mycorrhiza. Role of Mycorrhiza in Forestry.
   Diseases of cereals and Millets.
   Diseases of vegetables and fruit trees.

SUGGESTED READINGS:
2. Singh Dehradun.

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.

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.


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.


SUGGESTED READINGS:


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.


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.


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.


11. Introduction to nanotechnology and nanomaterials, special nanomaterials.


14. Application of nanotechnology in tissue repair, biotechnology, medical fields and cleaning up environment.

SUGGESTED READINGS

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-dimensional structure: CATH and SCOP, Protein structure prediction, Secondary structure prediction.
5. Microarray data analysis, tools and resources, Sequences sampling and SAGE, Analysing data from 2D-PAGE gels, Analysing protein mass spectrometry data, modeling and restructuring molecular pathways, Protein interaction informatics, Higher-order models.
6. Phylogenetics, cladistics and ontology; Building phylogenetic trees; Evolution of macromolecular sequences.
7. Chemoinformatic resources, Conventions in representing molecules, Pharmainformatics.

SUGGESTED READINGS

Database Sites
www.dnalc.org
www.hugo-international.org
www.ensembl.org

Paper XVI: 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.
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

7. Sing, T. Seed Technology and Seed Pathology . Pointer Publisher, Jaipur.

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.
8. Wood structure in relation to properties and uses.

**SUGGESTED READINGS**

3. Ramesh Rao, K and Junija. Field Identification of 50 important timbers of India, FRI.

**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 KNO₃ 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 CO₂ 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 C₃ and C₄ 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.
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 ($\alpha$) diversity, Beta ($\beta$) 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
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


Suggested Manuals for Ecological Exercises:

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.
5. Digital classification and Enhancement of satellite data, Information extraction using DIP techniques.

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.
4. Observations on Natural disasters viz., floods, landslides, forest fires frequent in Himalayas.
5. Visits to National Parks, Wildlife 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.


5. Study of the growth of pollen tube through stigma and style.


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)
4. Effect of pretreatments on germination of seeds.
5. Propagating different plants by using budding and layering in the field at some horticultural station,
6. Plant propagation by cutting and layering techniques.
7. Propagation through specialized vegetative structures and micro propagation.
8. Preparation of different types of tissue culture media.
10. Regeneration of plants from callus.
11. Micropropagation of plants using different explants.

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.
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.

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:

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.
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.
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.
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.
14. Ecosystem restoration, Strategies and plans for restoration, Passive restoration (natural recovery) and active restoration.

SUGGESTED READINGS

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.
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 fingerprinting.
8. Microbial genetic manipulation: Bacterial transformation, selection of recombinants and transformants, genetic improvement of industrial microbes and nitrogen fixers, fermentation technology.
9. Genomics and proteomics: Genetic and physical mapping of genes, molecular markers for introgression of useful traits, artificial chromosomes, high throughput sequencing, genome projects, bioinformatics, functional genomics, microarrays, protein profiling and its significance.
SUGGESTED READINGS:

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**

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:

<table>
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<th>Component</th>
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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

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<td>MBC102</td>
<td>Virology</td>
<td>03</td>
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<tr>
<td>MBC103</td>
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<td>MBC104</td>
<td>Biochemistry &amp; Microbial Physiology</td>
<td>03</td>
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<td>MBC105</td>
<td>Laboratory Course I**</td>
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<tr>
<td>MBC106</td>
<td>Laboratory Course II</td>
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**Core Credits= 18**

### M. Sc. Semester II

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<td>Molecular Biology &amp; Microbial Genetics</td>
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<td>MBC109</td>
<td>Immunology</td>
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<td>MBC110</td>
<td>Food Microbiology</td>
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**Core Credits= 18 with additional 03 Credits of Self Study (Seminar)**

### M. Sc. Semester III

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<td>MBC114</td>
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<td>MBE115</td>
<td>a. Recombinant DNA Technology</td>
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<td>MBE116</td>
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<tr>
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<td>Laboratory Course II</td>
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**Core Credits 09+ Elective Credits 09; Total Credits= 18+ 03 Credits of Self Study**

### M. Sc. Semester IV

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<th>Code</th>
<th>Paper</th>
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<tr>
<td>MBC119</td>
<td>Microbial Diversity including Extremophiles</td>
<td>03</td>
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<td>MBC120</td>
<td>Biostatics &amp; Computer Application</td>
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<td>MBC121</td>
<td>Laboratory Course I</td>
<td>03</td>
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<tr>
<td>MBE122</td>
<td>Dissertation</td>
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**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**

**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:

MBC102 Virology

Unit I

Unit II

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, Lambda.

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 pathogenicity, 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:


MBC103 Mycology and Phycology

Unit I

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, pneumocystis, blastomycoses, dematophytoses.

Unit III

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

Suggested Reading:

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

Unit III
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\textsubscript{2} in bacteria, heterotrophic CO\textsubscript{2} 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

Suggested Reading:
5. Stryer. 2001. Biochemistry. 5\textsuperscript{th} ed. WH Freeman.

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.
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).
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.
8. Estimation of sugar 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.
15. Study of red light induced akinete formation in cyanobacteria.
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). Asymmetric and dimeric nature of DNA polymerase, exonuclease activity in eukaryotic DNA polymerases.

Unit II

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 monocistronic 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

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

Suggested Reading:
MBC108 Medical Microbiology

Unit I

Unit II

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*, *Haemophilus, Bordetella, Brucella, Mycobacterium*, Spirochaetes, Actinomycetes, Rickettsiae, Chlamydiae.

Unit IV

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:

MBC109 Immunology

Unit I

Unit II

Unit III

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:
4. Christopher & David. Principle & Practice of Immunoassay 2nd Ed. –

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

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

Unit V
Suggested Reading:

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.
13. Demonstration of Koch’s postulates.
15. Isolation of dermatophytic microflora and their identification.
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 canned 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. Aeroallergy 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

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

Suggested Reading:

**MBC114 Industrial Microbiology**

**Unit I**

**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:**
2. Industrial Microbiology. G. Reed (Editor).CBS Publi (AVI Publishing Co.)
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

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

Suggested Reading:
MBE115b Soil Microbiology

Unit-I

Unit-II

Unit-III

Unit-IV

Unit-V

Suggested Reading:
MBE116a Cellular Microbiology

Unit-I

Unit-II

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

Unit-V

Suggested Reading:
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 (CO₂, CH₄, N₂O, CFCs; sources, trends and role); Ozone layer and ozone hole; consequences of climate changes (CO₂ fertilization, global warming, sea level rise, UV radiation).

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:

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.
10. Screening of various industrial enzymes from soil bacteria using plate assay (Zone of Hydrolysis).

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.
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.
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.
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 ($\alpha$), Beta ($\beta$) 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

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:

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, sterility 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

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

Suggested Reading:
4. E Balaguru Swamy. Programming in C.
5. J. Liberty. C++ from scratch.

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

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<td>II.</td>
<td>Bacteria, Virus &amp; Protozoa</td>
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<td>III.</td>
<td>Algae, Fungi &amp; Plant Pathology</td>
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<td>IV.</td>
<td>Microbial Physiology &amp; Biochemistry</td>
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<td>V.</td>
<td>Microbial Genetics &amp; Molecular Biology</td>
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<td>VI.</td>
<td>Biostatistics, Bioinformatics &amp; Computer application</td>
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<td>III Year</td>
<td>VII.</td>
<td>Environmental Microbiology</td>
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<td>Industrial Microbiology</td>
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<td>IX.</td>
<td>Medical Microbiology &amp; Immunology</td>
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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, thermocycler (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:
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

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, Lambda.

Unit V

Suggested Readings:
Paper III. Algae, Fungi & Plant Pathology

Unit I

Unit II

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

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:

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.
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.
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

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:
Paper V. Microbial Genetics & Molecular Biology

Unit I
Nucleic acids as genetic information carrier: Experimental evidence. DNA structure, Historical aspects and current concepts. DNA replication, General principles, various modes of replication.

Unit II

Unit III

Unit IV

Unit V
Gene conversion, site specific recombination, transposable elements, nomenclature, insertion sequences, transposons.

Suggested Readings:
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

Suggested Readings:
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.
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.
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.
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:
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

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

Unit V

Suggested Readings:
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

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:

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.
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 1
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

Unit -4
1. Lichens: Occurrence, physiology (symbiotic relationship) and general structure.
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 generation in 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, agamospor 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
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
2. Collection and preservation techniques of specimens for herbarium and museum.

Unite-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
Unit-5
1. Biodiversity: Basic concept, biodiversity at global and national level, causes of loss of biodiversity.
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 transition.

Unit-2
1. Secretory structure.
2. Origin, structure and function of vascular cambium including anomalous behavior with special reference to the following taxa: Bougainvillea, Salvadoria, 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
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.

Unit-3
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 Structure and function of other organelles: Golgi, ER, peroxisomes, Vacuoles, The

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 mitochondrial and plastid DNA, plasmids.

Unit-II
2. Interaction assortment, incomplete linkage, linkage groups; Crossing over.
3. Sex linked inheritance; Determination of sex.

Unit- III
1. DNA the genetic material: DNA structure, replication DNA –DNA.
2. RNA structure and type.

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 mapping 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 delivery 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).

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.
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.

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
4. Carbohydrates- classification, properties, structures and biological role.
6. Lipids: structures and functions, fatty acid biosynthesis, B-oxidation, saturated and unsaturated fatty acids, storage and mobilization 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 polyphylatic origin; centre of origin of some important crop plants.

Unit-2
1. Origin, 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.
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.