

DEPARTMENT OF BOTANY
Proposed structure for UG and PG Botany course

(Semester System)

Syllabus

To be applicable from 2022-2023

KUMAUN UNIVERSITY
NAINITAL

Curriculum Design Committee, Uttarakhand

S. No.	Name & Designation
1.	Prof. N.K. Joshi Vice-Chancellor, Sridev Suman Uttarakhand University, New Tehri Chairman
2.	Vice-Chancellor, Kumaun University, Nainital Member
3.	Prof. Jagat Singh Bisht Vice-Chancellor, Soban Singh Jeena University Almora Member
4.	Prof. Surekha Dangwal Vice-Chancellor, Doon University, Dehradun Member
5.	Prof. O. P. S. Negi Vice-Chancellor, Uttarakhand Open University, Haldwani Member
6.	Prof. M.S.M. Rawat Advisor, Rashtriya Uchchatar Shiksha Abhiyan, Uttarakhand Member
7.	Prof. K. D. Purohit Advisor, Rashtriya Uchchatar Shiksha Abhiyan, Uttarakhand Member

Semester-I

Lower Botany (ALGAE, BRYOPHYTA, FUNGI)

Introduction and salient features of algae and their place among the organism.

Classification of algae (Smith) up to class level and basis of classification.

Range of vegetative structure of algae. Cell structure of Prokaryotic and Eukaryotic algae.

Reproduction, types of life cycles (haplontic, diplontic, diplohaplontic, haplodiplontic and diplobiontic) and alternation of generation in algae.

Ecology of algae-brief idea of fresh water and marine, terrestrial, epiphytic, parasitic, symbiotic algae and phytoplanktons.

Economic importance of algae as food, fodder, in agriculture, industry and public health.

Structure, reproduction and life cycles of the following genera-

Nostoc, Chlamydomonas, Volvox, Oedogonium, Chara, Vaucheria, Ectocarpus, Sargassum, Polysiphonia, Diatoms.

Introduction, salient features, distribution, habit and habitat and economic importance of Bryophyta.

A brief account of alternation of generation in Bryophyta.

Classification of Bryophyta (Rothmaler/Schuster) upto order level giving the characteristic features of each class.

Study the following genera on the basis of morphology and anatomy of gametophyte, vegetative, sexual reproduction and sporophyte: *Riccia, Marchantia, Pellia, Anthoceros and Funaria*

Introduction and salient features of Fungi. A brief history of the study of fungi and their place among the organisms.

A broad outline of classification of fungi(Ainsworth) up to the class level

Somatic structure of fungi, nutritional and environmental needs of fungi.

Reproduction in fungi: asexual and sexual reproduction, heterothallism (two allelomorph heterothallism only), heterokaryosis, a general idea of parasexual cycle.

Pathology of fungal plant diseases: A brief idea about disease symptoms, control of plant diseases; brief idea about the exclusion, eradication and protection of plants.

Importance of fungi both beneficial and harmful.

Life history of the following genera in brief:

Stemonitis, Synchytrium, Saprolegnia, Albugo, Rhizopus, Penicillium, Eryshiphe, Morchella, Ustilago, Puccinia, Agaricus, Alternaria.

Lab course (Practical)

Algae

- A. To study and identify the following algal material by preparing the temporary slides: Nostoc, Chlamydomonas, Chara, Oedogonium, Spirogyra, Vaucheria, Sargassum, Fucus, Polysiphonia including some genera available at local level.
- B. To study and comment upon the specimens/slides of the given material.

Bryophyta

- A. To study the morphological and anatomical features of the following material and identify them: Riccia, Marchantia, Pellia, Anthoceros, Funaria or locally available material.
- B. To comment upon the specimens/slides given.

Fungi

- A. To study and identify the following fungal material by preparing the temporary slides: Albugo, Rhizopus, Mucor, Penicillium, Aspergillus, Puccinia, Ustilago, Alternaria.
- B. To study and comment upon the following specimens/slides of fungi: Morchella, Agaricus, Smut, Rust, Powdery mildew, White rust, Synchytrium, Spores of Puccinia, Conidia of Alternaria

Suggested readings:

1. Kumar H.D. 1999. Introductory phycology. Affiliated East West Press, New Delhi.
2. Parihar, N.S. 1991. An introduction to bryophyta Vol I. Central Book Depot Allahabad.
3. Parihar, N.S. 1991. An introduction to bryophyta Vol II. Central Book Depot Allahabad.
4. Vashishta, B.R., Sinha A.K. 2012 Botany for degree students: Fungi. S.Chand New Delhi
5. Vashishta, B.R., Sinha A.K. and Singh, V.P 2012 Botany for degree students: Algae. S.Chand New Delhi
6. Vashishta, P.C., Sinha A.K. and Kumar Adarsh. 2012. Botany for degree students: Bryophyta. S. Chand, New Delhi
7. Matthews, R.E. 2013 Fundamentals of Plant Virology ELSEVIER India
Tandan, Neeraj 2014 Advances in Microbiology. Anmol
8. Tauro, P. 1986. An Introduction to Microbiology. New Age International

Semester-II
PTERIDOPHYTA, GYMNOSPERMS AND ECOLOGY

PTERIDOPHYTA

1. Introduction and salient features of Pteridophyta and economic importance.
2. Alternation of generation in Pteridophyta.
3. Classification of Pteridophyta(Bierhort) upto order level pointing out the features of special significance of each class.
4. Studies on Rhynia, Lycopodium, Selaginella, Equisetum, Adiantum on the basis of morphology and anatomy of vegetative plant body, spore producing organs and sexual reproduction.
5. Stelar system, heterospory, seed habit and Telome theory.

GYMNOSPERMS

1. Introduction and salient features of Gymnosperms and their place among the plant kingdom.
2. Classification of gymnosperms upto order level pointing out the features of special significance of each class.
3. Alternation of generation in Gymnosperms.
4. Comparative study of Cycas, Pinus and Ephedra on the basis of morphology and anatomy of the vegetative plant body, sporophylls (their arrangement) and sporangia, spores, male and female gametophytes, pollination, fertilization, embryology and seed germination.

ECOLOGY

1. Plant and environment: Principles of environment, atmosphere, light, temperature, water, soil.
2. Morphological, anatomical and physiological responses of plants to water (Hydrophytes and Xerophytes): temperature (thermoperiodism and vernalization): light (heliophytes and sciophytes).
3. Population: Growth curves, ecotype and ecads.
4. Definition of community, Structure and attributes of community: frequency, density, cover, life forms and biological spectrum, ecological succession.
5. Ecosystem concept, energy flow, food chain, food web and ecological pyramids.
6. Biogeochemical cycles with emphasis on carbon and nitrogen cycles.

7. Preliminary idea of environmental pollution-air, water, soil, noise and radioactive pollution.

Lab course (Practical)

PTERIDOPHYTA

- A. To study the anatomical features of the following material and identify them:
Lycopodium, Sellaginella, Equisetum, fern sorus, Adiantum
- B. To comment upon the specimens/slides given.

GYMNOSPERMS

- A. To study the anatomical features of the following material and identify them:
Cycas leaflet, Pine needle, Pine stem (T.S., T.L.S., R.L.S.), male and female cone of Pinus, Ephedra
- B. To comment upon the specimens/slides given.

ECOLOGY

- A. To calculate the frequency, abundance, density and A/F ratio of the given data.
- B. To calculate the relative frequency, relative density, relative abundance and IVI of the given data by quadrat method and by developing artificial vegetation plots.
- C. To determine the leaf area of the given leaves.
- D. To calculate net primary productivity of a grass land
- E. To Study the soil pH and soil moisture content.
- F. To develop population structure diagram
- G. To calculate the mean, median and mode by analyzing the given data of individual, discrete and continuous series.
- H. To calculate the standard error and deviation
- I. To calculate the correlation coefficient
- J. To calculate the chi square value
- K. Xerophytic stem: Casuarina, Calotropis; Hydrophytic stem: Hydrilla, Nymphaea

Suggested readings:

Bhatnagar S.P. and Moitra A. 1996. Gymnosperms. New Age International, Pvt Ltd (P) New Delhi.

Vashishta, P.C., Sinha A.K. and Kumar Anil. 2012 Botany for degree students: Gymnosperm. S. Chand, New Delhi

Vashishta, P.C., Sinha A.K. and Kumar Anil. Botany for degree students: 2012 Pteridophyta. S. Chand, New Delhi

Sharma, P.D. 2014. (12th Edition). Ecology and Environment . Rastogi Publications, Meerut.

Shukla R.S. and Chandel, P.S. 2014. Plant Ecology. S. Chand, New Delhi.

Shukla, R.S. and Chandel, P.S. Biostatistics. S. Chand & Sons, New Delhi.

MINOR/ ELECTIVE PAPER 1: ELEMENTARY MICROBIOLOGY

DIVERSITY OF MICROBIOLOGY: A GENERAL ACCOUNT

- Archaeobacteria and Eubacteria: General account, Gram positive and Gram negative bacteria, nutrition, reproduction and economic importance.
- Viruses: Characteristics, chemical nature, replication, transmission of viruses, economic importance.
- Lichens: Characteristics, general structure, reproduction, economic importance, symbiotic relationship and habitats.

MINOR/ ELECTIVE PAPER 2: PALEOBOTANY

- Fossils and their types
- Fossilization
- Geological time scale

MINOR/ ELECTIVE PAPER 3: BIOSTATISTICS

- Introduction, definition, scope and importance of statistics.
- Sampling: aim, simple random sampling, stratified random sampling, systematic sampling.
- Measures of central tendency: mean, median and mode.
- Classification, tabulation and graphic presentation of data measures of dispersion-range, variance, standard deviation, standard error, Chi-square test, Correlation: correlation coefficient.

SEMESTER-III

TAXONOMY OF ANGIOSPERMS AND PLANT ANATOMY

1. Basic principles and broad outline of the classification proposal by Bentham and Hooker and Hutchinson.
2. International Code of Botanical Nomenclature.
3. Botanical gardens and Herbaria and Botanical Survey of India,
4. Distinguishing features of the following families Ranunculaceae, Brassicaceae, Caryophyllaceae, Rutaceae, Fabaceae, Rosaceae, Apiaceae, Asteraceae, Solanaceae, Lamiaceae, Orchidaceae, Liliaceae, Poaceae.

PLANT ANATOMY

1. Meristematic tissues: Root and Shoot apical meristems and their function; Permanent tissues Simple, Complex and Special types of tissues.
2. Epidermal tissue system: stomata and epidermal outgrowth.
3. Anatomy of dicot root, stem and leaf.
4. Anatomy of monocot root, stem and leaf.
5. Root-stem transition
6. Secondary growth: vascular cambium, structure and function.
7. Secondary growth in root and stem: seasonal activity, annual ring, sapwood, heart wood.
8. Anomalous secondary growth in dicot and monocot stem and root.

LAB COURSE (PRACTICAL)

TAXONOMY OF ANGIOSPERMS

- A. To identify the flowering twigs of given families by studying the taxonomic characters using technical terms: At least two specimens from each family should be studied: Ranunculaceae, Brassicaceae, Malvaceae, Caryophyllaceae, Rosaceae, Fabaceae, Apiaceae, Asteraceae, Solanaceae, Lamiaceae, Liliaceae, Poaceae.

PLANT ANATOMY

A. To study the anatomical characters of different plant organs of monocots and dicots by preparing temporary slides of transverse and vertical transverse sections of the following material and identify them.

Monocot root: Maize

Dicot root: Sunflower or any other

Epiphytic root: Orchid and Ficus

Monocot stem: Maize, Cynodon

Dicot stem: Sunflower and Cucurbita

Monocot leaf: Maize or any grass leaf

Dicot leaf: Nerium, Mango

Anomalous features: *Mirabilis*, *Anemone*, *Bignonia*, *Boerhaavia*, *Nyctanthes*, *Salvadora*, *Leptedenia*, *Dracena* and *Beta vulgaris* root. To study the slides

Suggested readings:

Bhojwani, S.S., Bhatnagar, S.P., Dantu, P.R. The Embryology of Angiosperms-6th Edition. Vikas Publishing House. New Delhi.

Saxena, N.B. and Saxena, S. 2009. Plant Taxonomy. Pragati Prakashan Meerut.

Simpson M.G. 2006. Plant systematics. Elsevier Academic Press San Diago. CA, USA

Singh V and Jain D.K. 2012. Taxonomy of Angiosperms. Rastogi Publications, Meerut.

Singh, G. 2012. Plant systematic. Theory and practice. Oxford and IBH Pvt. Ltd.

SEMESTER-IV

EMBRYOLOGY

1. Structure of anther and pollen, microsporogenesis and male gametophyte.
2. Structure and types of ovules, megasporogenesis and female gametophyte.
3. Pollination mechanism, Fertilization, double fertilization.
4. Endosperm types, dicot and monocot embryo.
5. General concept of morphogenesis.
6. Seed germination and dormancy.

Suggested readings:

Easu, K. Anatomy of seed plants. Wiley Eastern Pvt Ltd. New Delhi.

Metcalf, C.R and Chalk, L 1983. Anatomy of Dicotyledons and Monocotyledons. 2 vols. Clarendon Press, Oxford.

Pandey, S.N. Plant Anatomy. Rastogi Publication Meerut.

Singh, B.D. 2002. Plant Breeding Principles and Methods. Kalyani Publ. New Delhi

MINOR/ ELECTIVE PAPER 1: ECONOMIC BOTANY

A brief knowledge of Botany and commercial utilization and uses of the following plants:

1. Cereals and millets- wheat, rice and maize, Ragi, Pearl millet
2. Sugar yielding plants- Sugarcane and Sugar beet
3. Fruits- Mango, apple, banana, Citrus and Litchi.
4. Fibers- Cotton, jute, hemp, coir, Agave and Semal.
5. Vegetables- Root vegetables, stem vegetables and fruit vegetables.
6. Timbers- Teak, shisham, sal, chir and deodar.
7. Medicinal plants- *Aconitum*, *Atropa*, *Cinchona*, *Rauwolfia*, *Ephedra* and *Withania*.
8. Oils, Beverages, Fumitories, masticatories, Spices and Condiments yielding plants.

MINOR/ELECTIVE PAPER 2: MORPHOGENESIS OF PLANTS

1. Elementary movements.
2. A general account of Plant Growth Regulators.
3. Physiology of Flowering- Photoperiodism and Vernalization.

MINOR/ ELECTIVE PAPER 3: PLANT BREEDING

1. Plant breeding: aims and objectives,
2. Basic techniques of plant breeding
3. Selection of plants for breeding ,
4. Plant introduction and acclimatization,
5. Hybridization of plants and mutational breeding,
6. Hybrid vigour

SEMESTER-V

PAPER 1: PLANT PHYSIOLOGY

1. Diffusion, osmosis, water potential and its components, Plasmolysis, Imbibition and Absorption of water, root pressure and guttation.
2. Transpiration and its significance, Factors affecting transpiration, mechanism of stomatal opening and closing.
3. Mineral nutrition: Essential elements, macro and micro nutrients, criteria of essentiality of elements, role of essential elements, minerals deficiency symptoms, Transport of ions across cell membrane, active and passive transport, carriers, channels and pumps.
4. Translocation in phloem: composition of phloem sap, girdling experiment, pressure flow model, phloem loading and unloading
5. Respiration: ATP- The biological currency, redox potential, aerobic and anaerobic respiration. Oxidative phosphorylation, Electron transport system, Pentose phosphate pathway fermentation, R.Q and factors affecting respiration.
6. Photosynthesis: photosynthetic pigments, mechanism of photosynthesis, light phase (excitation of chlorophyll, ATP and NADPH formation, PS I and PS II), Dark phase, Path of carbon in C₃ plants (C₃ cycle), C₄ plants (C₄ cycle), CAM pathway, photorespiration, factors affecting rate of photosynthesis.

PAPER 2: GENETICS AND BIOCHEMISTRY

1. Foundation of Biochemistry: Forces and interaction of biomolecules; chemical bonds-covalent and ionic bond; stabilizing interaction (Vander wall, electrostatic, hydrogen bonding, hydrophobic interaction, concept of pH, pKa, titration curve, acid, bases and buffers, Henderson Hasselbalch equation).
2. Carbohydrate: Classification into mono-, di- and poly- saccharides; Glyoxylate cycle, Pentose- phosphate pathway.
3. Protein: Basic aspects of protein conformation; protein synthesis (activation of amino acid, initiation, elongation, termination).
4. Fats and Lipids: Structure and function of lipids, saturated and unsaturated fatty acids; β -oxidation.

5. Enzymes: Classification; mechanism of action; factors affecting enzymes activities; concept of holoenzymes, apoenzyme and co-factors.

LAB COURSE (PRACTICAL)

PLANT PHYSIOLOGY

1. To demonstrate the process of diffusion.
2. To demonstrate the process of osmosis by potato/radish/egg osmoscope.
3. To demonstrate the process phenomenon of imbibition.
4. To demonstrate the process of respiration by Ganog's respiroscope To demonstrate that CO₂ is liberated in anaerobic respiration
5. To demonstrate the process of photosynthesis by inverted funnel method and Wilmott's bubbler.
6. To demonstrate that CO₂ is necessary for the process of photosynthesis To demonstrate that light is necessary for photosynthesis
7. To compare the rate of absorption with the rate of transpiration.
8. To measure the rate of transpiration by Ganong's potometer.
9. To compare the rate of transpiration on the two surfaces of a dorsiventral leaf by 4 leaf method and cobalt chloride paper method.
10. To measure the rate of photosynthesis in different light conditions.
11. To measure the R.Q. (respiratory quotient) in different respiratory substrate.
12. To separate the chlorophyll pigment by preparing the crude extract of spinach leaf and to separate the plant pigments by filter paper chromatography.

BIOCHEMISTRY

1. To test the proteins in milk and pulses by Xanthoproteic reaction, Millon's test, Biuret test.
2. To test the reducing and non reducing sugar in glucose/ sucrose in different plant samples by Fehling solution test, hydrolysis test.
3. To test the starch in: rice/wheat/potato/sweet potato by Iodine test
4. To test the fats /oils in different seeds/vegetable by Sudan test and Osmic acid test.

Suggested readings:

- o Jain, V.K. 2014 (17th edition). Fundamentals of plant physiology. S. Chand, New Delhi
- o Verma, S.K. and Verma M. 2014. A text book of Plant physiology, biochemistry and biotechnology. S. Chand, Meerut.

SEMESTER- VI

PAPER 1: CELL AND MOLECULAR BIOLOGY

1. Cell structure: Prokaryotic and eukaryotic cells; ultrastructure of eukaryotic cell, cell wall and plasma membrane (ultrastructure, chemical composition and models of plasma membrane).
2. Structure and functions of cell organelles: Mitochondria, Chloroplast, Endoplasmic reticulum, Golgi complex, Ribosome, Microbodies (Lysosomes, Peroxisomes, Glyoxisomes); structure and function of Nucleus and Nucleolus.
3. Cell division: cell cycle, process and significance of mitosis and meiosis and crossing over.
4. Eukaryotic chromosome: structure , chemical composition, Karyotype analysis, Ideogram; structure and functions of Polytene and Lampbrush chromosomes.
5. DNA chemistry and DNA replication; replication error and repair mechanism.
6. Molecular basis of gene mutation.
7. C-DNA and C-DNA library.
8. Molecular markers: A general idea of PCR and non PCR based markers.
9. Polymerase chain reaction techniques (PCR), a brief idea of DNA finger printing.

PAPER 2: BIOTECHNOLOGY

1. Introduction to Biotechnology: Role in modern life, history and ethical issues connected with Biotechnology.
2. Genetic Engineering: Recombinant DNA Technology, Enzymes and vectors involved in genetic engineering, Gene cloning steps and uses.
3. Plant tissue culture: Basic requirements of Tissue culture Laboratory, different types of media, General account of micropropagation, organogenesis, somatic embryogenesis and cryopreservation, protoplast isolation and fusion, somatic hybridization.
4. Industrial Biotechnology: With reference to drinks and beverages.
5. Biotechnology with regard to microorganisms: Mycotoxin based health hazards and their control, single cell protein.

LAB COURSE (PRACTICAL)

MOLECULAR BIOLOGY

- To study the working of following instruments: PCR, incubator,
- Gelectrophoretic assembly, water bath, Spectrophotometer, Gel documentation Unit and centrifuge etc.
- To study about life history of various scientists and their contribution in the field of Molecular Biology.
- To study the working of following instruments: PCR, Laminar air flow chamber, autoclave, incubator, and centrifuge.
- To study the Gram positive and Gram negative bacteria in root nodule, curd and soil.
- Culture media preparation.
- Sterilization techniques including surface sterilization of explants.
- Study the use of Azolla as biofertilizer
- Comment upon the given photographs, specimens etc.

Suggested reading:

Dubey, R.C. Advanced Biotechnology. S. Chand & Sons, New Delhi .
Chawala, H. S. Biotechnology

Semester VII

Paper I: Microbiology: Bacteria, Virus and Lichens

General account of Microorganisms: History of microbiology, Golden Era of Microbiology, characteristic features of bacteria, General account of actinomycetes, classification of microorganism-five kingdom classification, Microbial growth- measurement of microbial growth, Batch, Fed-batch and continuous culture.

Morphology and structure of Bacterial cells: Morphology of bacterial cells based on size, shape and arrangement, fine structure of bacterial cells (of both Gram negative and gram positive bacteria) capsule cell wall, cell appendages (flagella, fimbriae, pilli), structure of plasma membrane, cytoplasmic inclusions-mesosomes, chlorosome. Ribosome- Site of protein synthesis, Microbial genetics- transformation, conjugation and transduction.

Morphology and structure of viruses: History, morphology, fine structure, shape and classification of viruses. Mycophages and Prions, Tobacco mosaic virus(TMV), T4 Bacteriophage and HIV- their fine structure, genome organization and multiplication, bacteriophage therapy.

General account of lichens: Occurrence and distribution, trends in classification, morphological diversity, type forms and ecological groups anatomy (homeomerous and heteromerous), reproduction, Economic importance of lichens, Lichenic acid.

Suggested Readings:

Clifton, A. 1958. Introduction to the Bacteria. McGraw-Hill book Co., New York.

Mandahar, C.L. 1978. Introduction to Plant Viruses. Chand & Co. Ltd., Delhi.

Doelle, H.W. and C.G, Heden 1986. Applied Microbiology, Kulwer Academic Press, London.

Pelczar, M.J., Chan, ECS and Kreig, N.R. 1993. Microbiology, Concept ans Applications. McGraw Hill, New York.

Ross, F.C. 1983. Introductory Microbiology. Charles E. Merrill. Publ. Co. Columbus, Ohio.

Alexander, M. 1991. Microbial Ecology. John Wiley and Sons. New York.

Kaushik, P. 1996. Introductory Microbiology. Emkay Publ, Delhi.

Miller, B.M. and W. Litsky 1976. Industrial Microbiology. Mc Graw Hill New York.

Mukherjee, K.G. and Ved Pal Singh, 1997. Frontiers in Applied Microbiology. Rastogi Publ. Meerut.

- Norris, J.R. and D.W. Ribbons 1970. *Methods in Microbiology*. Academic Press, London.
- Power, C.B. and H.F. Dagainawala 1996. *General Microbiology 2 Vols*. Himalaya Pub. House, New Delhi.
- Ross, F.C. 1983. *Introductory Microbiology*. Charles E. Merrill Publ. Co. Columbus. Ohio.

Paper II: Phycology

History and Classification of Algae: Criteria of classification, important systems of classification, position of the Algae in the plant kingdom, Classes and Divisions of Algae, Characteristics of Divisions and classes of Algae

Importance of Algae: Useful and harmful aspects of algae

The Pigments of Algae: Pigments and chloroplasts, principal kinds of Algal pigments, properties of chlorophylls, carotenoids, phycobilins, pigments of Cyanophyceae, Chlorophyceae, Charophyceae, Xanthophyceae, Bacillariophyceae, Phaeophyceae and Rhodophyceae

Ecology of Algae: Diversified habitats of Algae, Eutrophication, water blooms and phytoplanktons
A detailed study of following orders with given genera

Cyanophyta: Chroococcales (*Chroococcus*, *Microcystis*), Oscillatoriales (*Oscillatoria* and *Lyngbya*), Nostocales (*Anabaena*, *Spirulina*), Rivulariales (*Rivularia*)

Chlorophyta: Chlamydomonadales (*Haematococcus*), Volvocales (*Pandorina*, *Eudorina*), Chlorococcales (*Chlorella*, *Hydrodictyon*), Cladophorales (*Cladophora*), Chaetophorales (*Coleochaete*, *Fritschiella*), Zygnemetales (*Zygnema*)
Charophyta:
Charales (*Chara*).

A detailed study of following orders with given genera
Xanthophyta: Heterosiphonales (*Botrydium*, *Vaucheria*)
Bacillariophyta: Pennales and Centrales (Pinnate diatoms and centric diatoms).

Phaeophyta: Ectocarpales (*Ectocarpus*), Laminariales (*Laminaria*), Fucales (*Sargassum*, *Fucus*)

Rhodophyta: Gigartinales (*Gracillaria*), Gelidiales (*Gelidium*), Ceramiales (*Polysiphonia*), Nemalionales (*Betrachospermum*).

Suggested Readings:

1. Fritsch, F.E. 1979. *The structure and Reproduction of Algae Vol.1 &2*. Bishan Singh Mahendra Pal Singh. Dehradun.

2. Kumar, H.D. 1988. Introductory Phycology. Affiliated East-West Press Ltd. N. Delhi
3. Morris, I. 1986. An introduction of Algae. Cambridge University Press U.K.
4. Prescott, G.W. 1984. Algae: A review, Bishan Singh Mahendra Pal Singh, Dehradun.
5. Trainer, F.R. 1978. Introductory Phycology. John Wiley and Sons. Inc
6. By Robert Edward Lee (2008) PHYCOLOGY. Colorado State University.
7. Gilbert M. Smith. 1951. Manual of Phycology, Waltham, Mass, U.S.A, Chronica Botanica Company.
8. Desikachary, T.V. 1984. Cyanophyta. ICAR, New Delhi.
9. Round, F.E. 1984. Ecology of Algae. Academic Press, London.
10. Tilden, J.F. 1968. The Algae and their Life Relations. Hafner Publishing Co. New York.

PAPER III: MYCOLOGY

General characteristics and Classification of Fungi

Reproduction in Fungi (vegetative, asexual and sexual)

Heterothallism and Heterokaryosis Parasexual cycle.

Recent trends in classification of Fungi

Phylogeny of Fungi

Importance of Fungi.

General account of the following classes of fungi with emphasis on the given genera:

Myxomycotina: *Stemonitis, Physarum*

Mastigomycotina: *Allomyces, Monoblepharis.*

Oomycotina: *Saprolegnia, Pythium, Phytophthora, Sclerospora.*

Zygomycotina: *Mucor, Pilobolus, Entomophthora.*

Ascomycotina: *Saccharomyces, Aspergillus, Talaromyces (Penicillium), Taphrina, Phyllactinia, Peziza, Cordiceps, Claviceps.*

Basidiomycotina: *Puccinia, Ustilago, Geastrum, Fomes, Uromyces.*

Deuteromycotina: *Fusarium, Cercospora, Pyricularia, Colletotrichum, Trichoderma, Helminthosporium.*

Suggested readings:

1. Mehrotra, R.S. and K.R. Aneja. 1999. An introduction to Mycology. New Age International Publisher.

2. Alexopoulos, C. J. and Mims C. W. 1979. Introductory Mycology. John Wiley and Sons. New York.
 3. Webster, I. 1979. Introductory Mycology. Cambridge University Press. New York.
 4. Ainsworth, G.C. 1976. Introduction to the history of Mycology. Academic Press. New York.
 5. Webster, J. 1985. Introduction to Fungi. Cambridge University Press. New York.
- Sati, S. C. and Belwal, M. 2012. Microbes Diversity and Biotechnology. Daya Publication.

PAPER IV: BRYOPHYTA AND PTERIDOPHYTA

Evolutionary Trends in Bryophytes; Bryology in India.

General idea about morphology, cytology and reproduction in Bryophyta.

Ecological and Economic Importance of bryophytes, Role of bryophytes in monitoring mineral deposition and as indicator of air pollution. Modern Systems of Classification of Bryophytes.

Salient features of the following groups with special reference to the genera given:

(A) Marchantiophyta

- (i) Sphaerocarpaceae- *Sphaerocarpos*
- (ii) Marchantiales- *Marchantia*, *Lunularia*, *Plagiochasma*, *Reboulia*, *Asterella*, *Cryptomitrium*, *Targionia*, *Conocephalum*, *Cyathodium*
- (iii) Jungermanniales- *Frullania*, *Porella*, *Radula*
- (iv) Metzgeriales- *Pellia*, *Sewardiella*, *Metzgeria*, *Riccardia*
- (v) Calobryales- *Haplomitrium*

(B) Anthocerotophyta

Anthocerotales- *Anthoceros*, *Foilioceros*, *Megaceros*, *Phaeoceros*, *Notothylas*

(C) Bryophyta

Sphgnales- *Sphagnum*

Andreales- *Andreaea*

Takakiales- *Takakia*

Eubryales- *Buxbaumia*, *Polytrichum*

A brief account of origin of pteridophytes, classification of pteridophytes, Heterospory and seed habit, evolution of stelar system, telome theory, Evolution of sorus, apogamy, apospory and apomixes.

A brief account of the class:

Psilophytopsida-*Rhynia*, *Horneophyton*

Psilotopsida-*Psilotum*

A brief account of the class

Lycopsidea-*Lycopodium*, *Lepidodendron*, *Lepidocarpon*, *Selaginella*, *Isoetes*

Sphenopsida-*Hyenia*, *Sphenophyllum*, *Calamites*, *Equisetum*

Pteropsida:

Eusporangiate -Ophioglossales

Protoleptosporangiate- *Osmunda*,

Leposporangiate: (a) Filicales - *Adiantum*

(b) Marsileales –*Marsilea*

(c) Salviniaceae - *Azolla*

Suggested Readings:

1. Parihar, N.S. 1991. Bryophyta. Central Book Depot, Allahabad.
 2. Puri, P. 1980. Bryophytes. Atma Ram & Sons, Delhi
 3. Ram Udar. Fifty years of Bryology in India. Golden Jubilee Series. IBS, New Delhi
 4. Smith, G.M. 1955. Cryptogamic Botany. Vol. I and II. Tata Mc Graw Hill, New Delhi.
- Parihar, N.S. 1996. Biology and Morphology of Pteridophytes. Central Book Depot Allahabad
- Sporne, K.R. 1991. The Morphology of Pteridophytes. Hutchinson Library Series London

PRACTICAL WORK

Types of Bacteria – Gram Negative and Gram positive Bacteria.

Identification and types of lichens.

Study of the following genera: Cyanophyceae, Chlorophyceae, Charophyceae, Xanthophyceae, Bacillariophyceae, Phaeophyceae and Rhodophyceae.

General account of the following classes of fungi with emphasis on the given genera:

Myxomycotina:*Stemonitis*, *Physarum*

Mastigomycotina:*Allomyces*, *Monoblepharis*.

Oomycotina:*Saprolegnia*, *Pythium*, *Phytophthora*, *Sclerospora*.

Zygomycotina:*Mucor*, *Pilobolus*, *Entomophthora*.

Ascomycotina: *Saccharomyces, Aspergillus, Talaromyces (Penicillium), Taphrina, Phyllactinia, Peziza, Cordiceps, Claviceps.*

Basidiomycotina: *Puccinia, Ustilago, Geastrum, Fomes, Uromyces.*

Deuteromycotina: *Fusarium, Cercospora, Pyricularia, Colletotrichum, Trichoderma, Helminthosporium.*

Salient features of the following groups with special reference to the genera given:

(B) Marchantiophyta

(i) Sphaerocarpaceae- *Sphaerocarpos*

(ii) Marchantiales- *Marchantia, Lunularia, Plagiochasma, Reboulia, Asterella, Cryptomitrium, Targionia, Conocephalum, Cyathodium*

(vi) Jungermanniales- *Frullania, Porella, Radula*

(vii) Metzgeriales- *Pellia, Sewardiella, Metzgeria, Riccardia*

(viii) Calobryales- *Haplomitrium*

(D) Anthocerotophyta

Anthocerotales- *Anthoceros, Foiliceros, Megaceros, Phaeoceros, Notothylas*

(E) Bryophyta

Sphagnales- *Sphagnum*

Andreales- *Andreaea*

Takakiales- *Takakia*

Eubryales- *Buxbaumia, Polytrichum*

Semester VIII

PAPER 1: GYMNOSPERMS AND PALEOBOTANY

Introduction: History, classification, distribution and evolution of gymnosperms

Brief account of the families of Pteridospermales (Lyginopteridaceae, Medullosaceae, Caytoniaceae and Glossopteridaceae)

General account of Cycadeoideales

General account of Cordaitales

General account of Pentoxylales

Morphology, anatomy and reproduction in Cycadales

Morphology, anatomy and reproduction in Ginkgoales

Morphology, anatomy and reproduction in Coniferales

General account of Ephedrales

General account of Welwitschiales

General account of Gnetales

Preservation of fossil plants

Types of fossils and modes of formation of different kinds of fossils

Gondwana flora

Suggested Reading

Bhatnagar S.P. and Moitra A 1996. Gymnosperms New Age International, Pvt Ltd (P) New Delhi
Vashishta, P.C., Sinha A.K. and Kumar Anil.2012. Botany for degree students: Gymnosperm. S. Chand, New Delhi.

PAPER 2: DIVERSITY AND TAXONOMY OF ANGIOSPERMS

Important system of classification Bentham & Hooker, J. Hutchinson and A. Takhtajan and their merits and demerits.

Salient features of International Code of Botanical Nomenclature.

The species concept: Taxonomic Hierarchy, species, genus, family and other categories. Principles used in assessing relationships, delimitation of taxa and attribution of rank.

Origin of intrapopulation variation. Population and the environment, ecads, ecotypes, evolution and differentiation of species.

Plant exploration in India with special reference to Uttarakhand.

Origin and evolution of angiosperms, Fossils, Type of inflorescence and their origin.

Taxonomic tools, herbarium, flora, histological, cytological, phytochemical, serological, biochemical, and molecular techniques.

Concepts of phytogeography, endemism, plant migration, invasions and introduction.

Distinguishing features only of the following families and their economic importance. Ranunculaceae, Rutaceae, Fabaceae, Asteraceae, Rosaceae, Lamiaceae, Asclepiaceae, Euphorbiaceae, Fagaceae, Violaceae, Convolvulaceae, Apiaceae, Acanthaceae, Rubiaceae, Solanaceae, Orchidaceae, Cyperaceae, Poaceae, Liliaceae.

Suggested readings

-Bensen L. 1957 Plant Classification. Reprint Oxford & IBH. N. Delhi.

-Davis and Heywood V.H. 1973. Principles of angiosperms taxonomy. Robert E. Kreign Pub. Co. New York.

-Gaur R.D. 1999. Flora of District Garhwal, N.W. Himalaya Transmedia, Srinagar Garhwal.

-Lawrence G.H.M. 1951. Taxonomy of vascular plants. Mac Millan N.York. -

Sambamurty A.V.S.S. Taxonomy of Angiosperms. I.K. International Pvt. Ltd

PAPER 3: PLANT DEVELOPMENT AND REPRODUCTIVE BIOLOGY

Morphology: Morphology of flower, Stamen and Carpel, Floral Characteristics, structure of the pistil, pollen stigma interactions, Plant adaptation – physiological and their morphological nature (xerophyte, hydrophyte and halophyte)

Shoot development: Organization of the shoot apical meristem (SAM): control of cell division and tissue differentiation, especially xylem and phloem: secretory ducts and laticifers

Leaf growth and differentiation, structural development and classification of stomata and trichomes.

Root Development: Organization of root apical meristem (RAM), vascular tissues differentiation, lateral root, root hairs.

Male gametophyte: Structure of anthers, microsporogenesis, role of tapetum, pollen development, pollen germination, pollen tube growth and guidance, pollen allergy,

Female gametophyte: Ovule development, megasporogenesis, development and organization of the embryo sac, structure of the embryo sac cells.

Pollination, pollen-pistil interaction and fertilization: pollination mechanism and vectors, sporophyte and gametophytic self-incompatibility, double fertilization.

Seed development and fruit growth: Endosperm development during early maturation and desiccation stages: embryogenesis, cell lineages during late embryo development, polyembryony, apomixes.

Latent life- dormancy: Importance and types of dormancy: seed dormancy, bud dormancy.

Suggested Readings:

The embryology of Angiosperms (2000 by S.S. Bhojwani and S.P. Bhatnagar. Vikas Publ. House. New Delhi.

Molecular embryology of flowering plants (1997) by V. Raghwan. Cambridge Univ. Press. Camb. Pollen biotechnology for crop production and improvements K.R. Shivanna and V.K. Sawhney. 1997. Cambridge Univ. Press.

Pollen biology by K. R. Shivanna and N.S. Rnagaswamy.

Fonkot De. 1994. Plant growth and Development. A molecular Approach. Academic Press. San Diego.

Howell. S.H. 1998. Molecular genetics of plant Development. Cambridge Univ. Press.

Leins P. Tucker. Sc & Endress P.K. 1988. Aspects of floral development. J. Cramer. Germany.

Lyndon. R.F. 1990. Plant Development. The Cellular Basis. Unnin Hyman. London.

Raghavan V. 1999. Developmental Biology of flowering plants. Springer Velag. New York.

Paper 4: Cytogenetics and Plant Breeding

Mendelian principles: Dominance, Segregation, independent assortment; extension of mendelian principles (codominance, incomplete dominance, gene interactions, pleiotropy); linkage and crossing over, sex linked, sex limited and sex influenced characters.

Genetic recombination and gene mapping: Recombination, role of Rec A and Rec B,C,D enzymes, gene mapping methods (linkage maps, tetrad analysis, mapping with molecular markers); population genetics- population, gene pool, gene frequency, Hardy-Wein Berg law

Structural and numerical alteration in chromosome: Origin, meiotic behaviour and consequences of duplication, deficiency, inversion and translocation; effect of aneuploidy on phenotypes in plants; transmission of monosomics and trisomics and their use in chromosome mapping of diploid and polyploidy species, evolution of major crop plants (wheat and rice)

Mutation: spontaneous and induced mutation; physical chemical mutagens; molecular basis of mutation; DNA damage and repair mechanisms; transposable elements, mutations induced by transposons; inherited human diseases; cell cycle and apoptosis, cancer at cellular level.

Chromosome structure: packing of DNA, molecular organization of centromere and telomere, nucleolus and ribosomal RNA genes; euchromatin and heterochromatin; Nuclear DNA content, C-value paradox; cot-curves and their significance

Gene structure and expression: genetic fine structure; cis-trans test; introns and exons; RNA splicing multiple alleles, pseudoallele, regulation of gene expression in prokaryotes and eukaryotes.

Suggested Readings:

1. Alberts, B., Bray, D., Lewis, J., Raff, M., Roberts, K. and Watson, J.D. 1989. *Molecular Biology of the Cell* (2nd Edition) Garland Publishing Inc., New York.
2. Atherly, A.G., Girton, J.R. and McDonald, J.F. 1999. *The Science of Genetics*. Saunders College Publishing, Fort Worth, USA.
3. Burnham, C.R. 1962. *Discussions in Cytogenetics*. Burgess Publishing Co. Minnesota.
4. Busch, C.R. and Rothblum, L. 1982. Volume X. *The Cell Nucleus rDNA Part A*. Academic Press.
5. Barry, J.M. and Barry, B.M. 1973. *Molecular Biology*, Prentice Hall of India. New Delhi.
6. Buchanan, B.B., Gruissem, W. and Jones, R.L. 2000. *Biochemistry and Molecular Biology of Plants*. American Society of Plant Physiologists, Maryland, USA.
7. De, D.N. 2000. *Plant Cell Vacuoles: An Introduction*. CSIRO Publication, Collingwood, Australia.
8. Gupta, P.K. 1998. *Cytogenetics*. Rastogi Publications, Meerut.
9. Hartl, D.L. and Jones, E.W. 1998. *Genetics: Principles and Analysis* (4th Edition). Jones and Bartlett Publishers, Massachusetts, USA.
10. Kleinsmith, L.J. and Kish, V.M. 1995. *Principles of Cell and Molecular Biology* (2nd Edition). Harper Collins College Publishers, New York, USA.
11. Krishnamurthy, K.V. 2000. *Methods of Cell Wall Cytochemistry*. CRC Press, Boca Raton, Florida.
12. Lewin, B. 2000. *Genes VII*. Oxford University Press, New York.
13. Lodish, H., Berk, A., Zipursky, S.L. Matsudaira, P., Baltimore, D and Darnell, I. 2000. *Molecular Cell Biology* (4th Edition). W.H. Freeman and Co., New York, USA.
14. Malacinski G.M., D. and Freifelder, D. 1998. *Essentials of Molecular Biology* (3rd Edition). Jones and Bartlett Publishers, Inc. London.
15. Stent, G.S. 1986. *Molecular genetics*. Bishen Singh Mahendra Pal Singh. Dehradun.
16. Watson, J.D. 1965. *Molecular Biology of the Genes*, Benjamin.
17. Wolfe, S.L. 1993. *Molecular and Cellular Biology*. Wadsworth Publishing Co. California.

Practical Work

Study of *Cycas*, *Pinus*, *Ephedra* and *Gingko*

Types of Fossils

Distinguishing features only of the following families and their economic importance.

Ranunculaceae, Rutaceae, Fabaceae, Asteraceae, Rosaceae, Lamiaceae, Asclepiaceae, Euphorbiaceae, Fagaceae, Violaceae, Convolvulaceae, Apiaceae, Acanthaceae, Rubiaceae, Solanaceae, Orchidaceae, Cyperaceae, Poaceae, Liliaceae.

Morphology of Flower,

Pollen grains and their types

Male and Female Gametophyte

Types of Ovules

Mitosis and meiosis

Chi-Square test

Various Genetic diseases

MINOR / ELECTIVE PAPER 1: GLOBAL CLIMATE CHANGE

General concept of Global climate change; Greenhouse effect; Greenhouse gasses; Carbon foot print; Impact of global warming and climate change especially on elevated temperature, weather extremes, ecosystem disruption, human health, sea level rise and impact on forests; International initiative for mitigating global changes; Inter governmental panel on climate change (IPCC); United Nation Framework convention on Climate change; Kyoto protocol; Montreal protocol; Paris Pact; India's initiatives for mitigating climate change.

MINOR/ ELECTIVE PAPER 2: MEDICINAL PLANTS OF CENTRAL HIMALAYA

Retrospect and prospects of medicinal plants

Brief history, properties, action and uses of some important medicinal plants

Diversity, distribution and indigenous uses of threatened medicinal plants

Government policies for conservation and management of threatened medicinal plants

Economics and exploitation of resources and people conflict.

MINOR/ ELECTIVE PAPER 3: PLANT CELL STRUCTURE AND FUNCTIONS

Principles of microscopy, structural organization of the plant cell and its chemical foundation, Cell wall structure and function, Plasma membrane, Cytoskeleton, organization and role of microtubules and microfilaments.

Structure and functions of endoplasmic reticulum, golgi apparatus, ribosomes and protein synthesis
Structure and genome organization of chloroplast and mitochondria

MINOR/ ELECTIVE PAPER 4: APPLIED MICROBIOLOGY

Microbiology and its scope: microorganisms in the living World: Group of microorganisms.
Occurrence and distribution of microorganisms in Nature. Major fields of applied microbiology.
Medical microbiology. Aquatic microbiology: Water purification microbiological examination;
biological degradation of waste; ecology. Aero microbiology. Food microbiology. Soil
Microbiology. Industrial microbiology. Geochemical microbiology. Mushroom cultivation and
Production of single cell protein and yeasts for fox.

Semester IX

PAPER 1: PLANT ECOLOGY

Climate, soil and vegetation patterns of the world: Major terrestrial biomes; Zonoecotones, Orobiomes and Pedobiomes, Fresh water aquatic ecosystems; Marine ecosystems; Vegetation Types and environmental factors.

Vegetation organization: Concepts of community and continuum; Community structure and attributes; Edges and ecotones; Keystone species and control of community structure. Species interactions: Types of interactions, interspecific competition ; Amensalism; herbivory; parasitism; Commensalism, carnivory, pollination, symbiosis (obligate and facultative symbiosis).

Population Ecology: Characteristics of population; population growth curves; population regulation life history strategies (r and k selection); population genetics and natural selection.

Habitat and niche: Concept of habitat and niche; niche width and overlap, fundamental and realized niche.

Ecological succession: Causes, mechanism and types, changes involved in succession; Transient and cyclic changes; Examples of succession; Methods of standing succession; concept of climax.

Ecosystem: Structure and functions; primary production (methods of measurement, Global pattern, Controlling factors); energy dynamics (Tropical 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 (pathways, processes in terrestrial and aquatic ecosystems); nutrient use efficiency; Global hydrological cycle.

Applied Ecology: Biodiversity concept; Levels of Biodiversity: genetic, species, community and ecosystem diversity; Uses of biodiversity; Biodiversity, Ecosystem services and functions; **Distribution of biodiversity;** Gradients of biodiversity; Hotspots; Threats to biodiversity; **Extinction of species;** Biodiversity assessment and inventory; Conservation of biodiversity; Indices; biodiversity and its conservation; International efforts for conserving biodiversity.

Environmental pollution: kinds; sources; quality parameters; effects on plants and ecosystems and remedies.

Climate change and conservation: Biology; Greenhouse gases; sources, trends and role; ozone layer and ozone hole; Consequences of climate change; principles of conservation; Major approach to management with special reference to Indian Biosphere reserves.

Suggested readings

Barbour, M.G., Burk, J.H. and Pitts, W.D. 1987 Terrestrial Plant Ecology.

Benjamin/Cummings Publication Company, California

Odum, E.P. 1983 Basic Ecology Saunders, Philadelphia

Smith, R.L. 1996 Ecology and Field Biology Harper Collins, New York

Baskin and Baskin 2001. Seeds: Ecology, Biogeography and Evolution of Dormancy and Germination Elsevier.

PAPER 2: PLANT RESOURCE UTILIZATION AND CONSERVATION

Sustainable development: Basic concepts.

World centres of primary diversity of domesticated plants: The Indo-Burmese centre plant introduction and secondary centres.

An idea of (i) Food, forage and fodder crops. (ii) Fibre crops. (iii) Medicinal and Aromatic Plants and (iv) Vegetable oil- yielding crops and their uses.

Important fire-wood and timber-yielding and non-timber forest products (NTFPs)

Such as bamboos, rattans, raw materials for paper-making, gums, tannins, dyes, resins and fruits.

Green revolution: Benefits and adverse consequences.

Plants used as avenue trees: for shade, pollution control and aesthetics.

Principles of conservation: extinctions: environmental status of plants based on International Union for Conservation of Nature (IUCN).

Strategies for conservation- in-situ conservation: International efforts and Indian initiatives; protected areas in India-sanctuaries, National Parks, biosphere reserves, wetlands, mangroves and coral reefs for conservation on wild biodiversity.

Strategies for conservation- ex-situ conservation: Principles and practices; botanical gardens, field gene banks, seed banks, in vitro repositories, cryobanks, general account of the activities of botanical Survey of India (BSI), National Bureau of Plant Genetic resources (NBPGR), Indian Council of Agriculture Research (ICAR), Council of Scientific and

Industrial Research (CSIR) and Department of Biotechnology (DBT) for conservation, non-formal conservation efforts.

Suggested Readings:

1. Global Biodiversity Assessment (1995) by V.H. Heywood and R.I. Watson.
2. Plant genetic resources Conservation and Management (1991) by R.S. Paroda and R.K. Arora.
3. The Conservation by Plant Diversity (1995) O.H. Frankel, A.D.H. Brown and J.J. Burdon.
4. Technical guidelines for the site movement of Germplasm (1989) by FAO IBPGR.

PAPER 3: BIOTECHNOLOGY

Biotechnology: Principle and scope, bio-safety guidelines.

Plant cell and tissue culture: Concept of cellular totipotency, principle of root and shoot generation in vitro, clonal propagation, applications of cell and tissue culture.

Callus culture, organ culture, cell suspension culture, cryopreservation, protoplast culture, organogenesis, somatic embryogenesis, artificial seed, somatic hybridization, hybrids and cybrids, and somaclonal variation.

Recombinant DNA technology: Tools of genetic engineering, enzymes, cloning vectors, plasmids, cosmids, lamda phage, shuttle vectors, BACs, and YACs. Cloning strategies, Screening and selection of transformants.

Gene libraries (a general account): Genomic DNA libraries, cDNA libraries Hybridization- colony hybridization, Southern hybridization, Northern hybridization, Western hybridization, DNA sequencing techniques: Concept of nucleic acid sequencing, Maxam and Gilbert sequencing, Sanger sequencing Genetic Engineering of plants: Aims, tools, strategies for development of transgenic plant with suitable examples.

Suggested Readings:

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

PAPER 4: PLANT PHYSIOLOGY AND BIOCHEMISTRY

Membrane transport and translocation of water and solutes: Plant –water relations, mechanism of water transport through xylem, phloem loading and unloading, passive and active solute transport, membrane transport of proteins.

Enzymology: General aspects, allosteric mechanism, regulatory and active sites, isozymes, kinetics of enzymatic analysis, Michaelis - Menten equation and its significance.

Signal transduction and sensory photobiology: Receptors, phospholipids signaling, phytochromes and cryptochromes.

Photosynthesis: General concepts and historical background, steps of photosynthesis, Emerson's effect, two pigment systems, Calvin cycle, photorespiration and its significance.

C4 cycle, CAM pathway

Respiration: Glycolysis. TCA cycle, electron transport chain and ATP synthesis, pentose-phosphate pathway, glyoxylate cycle.

Nitrogen fixation and metabolism: Biological nitrogen fixation, mechanism of nitrate uptake and reduction, ammonium assimilation.

Plant growth regulators: Physiological effects and mechanism of auxins, gibberellins, cytokinins, ethylene, abscisic acid, polyamines, jasmonic acid, hormone receptors and vitamins and hormones, phytochrome and cryptochrome.

Photoperiodism and vernalization: Photoperiodism and its significance, floral induction and development, significance of vernalization.

Stress physiology: Plant responses to biotic and abiotic stress, mechanism of biotic and abiotic stress tolerance, water deficit and drought resistance, salinity stress, freezing and heat stress, oxidative stress.

Carbohydrates: structure and function of Monosaccharides, oligosaccharides, polysaccharides.

Lipids: Fat metabolism (Simple lipids, compound lipids, derived lipids).

Proteins: Amino acids, Structure of primary, secondary and tertiary proteins, protein sequencing.

Suggested Readings:

1. Buchanan, B B; W. Gruissem and R. L. Jones.1996. Biochemistry and Molecular Biology of plants by Enzymes: A practical introduction to structure, mechanism and data analysis. R. A. Copeland.

2. Devi, P. 2000. Principles and methods of plant Molecular Biology, Biochemistry and Genetics.
3. Dennins, D. T; D.H. Turpin; D.D. Lefebvre and D.B. Layzell. Plant Metabolism.
4. Scott, R.P.W. 1995. Techniques and Practice of Chromatography.
5. Hopkins, W. G. 1995. Introduction to plant physiology.
6. Cooper, T.G. 1977. Tools in Biochemistry.
7. Salisbury & Ross 2003. Plant Physiology.
8. Lehninzer. Principles of Biotechnology
9. Srivastava, H.S. 1983. Elements of Biochemistry. Rastogi Publications, Merrut
10. Meister ,A . 1965. Biochemistry of the Amino acids. 2 vols. Academic Press, New York.
11. Bosch, C. 1972. Mechanism of Protein Synthesis and its Regulation. ElsevierPub. Comp. N.
12. York.
13. Summer, J. B. and G. F. Somers-1953. Chemistry and Methods of Enzymes. Academic Press, New York.
14. Ribonsen, T. 1968. The biochemistry of Alkaloides Springer Verlog, Berlin.

Practical Work

1. Population Structure and Study
2. BOD determination
3. Biodiversity Assessment
4. **World centres of primary diversity of domesticated plants**
5. Various resources:
 - (i) Food, forage and fodder crops. (ii) Fibre crops. (iii) Medicinal and Aromatic Plants and (iv) Vegetable oil- yielding crops and their uses.
6. **Non-timber forest products (NTFPs)** Such as bamboos, rattans, raw materials for paper-making, gums, tannins, dyes, resins and fruits.
7. **Plants used as avenue trees:** for shade, pollution control and aesthetics.
8. In situ/ Ex situ Conservation
9. Laboratory instruments
10. Biosafety Guidelines
11. Propagation techniques

12. Photoynthesis, Respiration, Growth Hormones

13. Test of Carbohydrate, lipid and Proteins.

SEMESTER X

PAPER 1: ENVIRONMENTAL BIOLOGY

Environment: Definition, major components of physical environment, Geosphere, lithosphere, hydrosphere, atmosphere and outer space. Impact of man and physical environment and vice-versa.

Resource and Energy Conservations: Concepts of resources, renewable and non-renewable resources, resource conservation, soil, water and forest resources, wild life resources, wild life management laws and principle, wild life sanctuaries, national parks and biosphere reserves. Introduction to various energy resources such as solar, wind, biomass, thermal, nuclear and biogas. energy conservation pattern and strategies.

Environmental monitoring: Meaning and scope, Environmental monitoring as a tool to environmental management concept of bio monitoring and biological indicator, biodiversity indices, environmental monitoring system.

Ecotoxicology: Branches and its significance, types of toxicants, toxic elements, organometallic and organometalloids, toxic inorganic and organic compounds, toxic natural products national and international laws of toxicology, radiation, ecology and recycling.

Environmental Pollutions: Definition, types and cause of pollution, air pollution, carbon, sulphur and nitrogen pollution, acid rains, ozone fluorocarbon hydrocarbons, metal photochemical products, water pollution sources of pollution and the pollutants, solid waste pollution, degradation and cycling of water, noise pollution, radioactive pollution and the pollutants, global warming and climate change, legal aspects of environmental pollution. Indian laws and policies for control of environmental pollution.

Environmental Impact Assessment: Scope, importance and applications of EIA process. Its role in protection and conservation of environment and economic resources, environmental and socio-economic aspects environmental priorities in India.

Environmental Management: Definition and basic concept, sustainable development environmental issues challenges and strategies in management, eco-planning, national and international organization and policies on environmental management, environmental management with special reference to land, water and forest resources, environmental education and awareness. Environmental laws.

References:

1. Energy, Environment and Natural resources- J.S. Singh, S.P. Singh and S.R. Gupta
2. Environmental Sciences- G.T. Miller
3. Environmental Science- R.T. Wright
4. Environmental Science- Piyush Malviya and Pratibha Singh
5. Environmental Science and Impact Assessment- S.C. Santra
6. Fundamental of Ecology- E.P. Odum
7. Ecology and Environment- P.D. Sharama
8. Environmental Concepts and Strategies- T.N. Khoshoo

PAPER 2: FOREST ECOLOGY

General Aspects of Forests: Forest ecology and forest ecosystem, Importance of forests in environmental conservation, Wildlife biodiversity and Climate change.

Primary Productivity and Detritus Pool: Solar radiation and energy units; Concept of primary productivity.

Formulations of Primary Productivity: Photosynthetic pathways and their significance; photosynthetic capacity; distribution of biomass; Allocation of Net primary production and accumulation of biomass; Measurement of biomass and primary productivity in forest ecosystems of the world; Plant biomass and turnover ; efficiency of energy Capture ; **Human Use of Productivity;** Environmental factors and productivity.

Litter Fall in Forest Ecosystems; determining litter fall, factors affecting it; Forest litter: type of litter; Coarse Woody debris; forest floor litter mass.

Detritus Pathway of Energy Flow and Decomposition Processes: Decomposer organisms and their trophic interactions; decomposition processes; Measurements of Litter Decomposition; Decomposition rate.

Nutrient Cycling in Forest Ecosystems: The nutrient cycle models in forest ecosystem;

Ecosystem Inputs of Nutrients: Atmosphere, Weathering of rock minerals, Hydrologic inputs, Biological inputs, biotic accumulation and storage of nutrients in plants; Nutrient outputs (Ecosystem losses). Stream water losses, losses to the atmosphere; Nutrient losses due to fire, nutrient losses in forest harvest;

Intra-System Cycle: Availability of nutrients in soil solution; Nutrient supply and uptake , Role of mycorrhizae in nutrient cycling; Nutrient concentration and storage in vegetation; Nutrient

reabsorption; Nutrient return from vegetation to soil; Decomposition and nutrient release, nutrient use efficiency, nutrient conserving adaptation in oligotrophic soil; Effects of N and P enrichment on biodiversity.

Forest Hydrology: Impact of forest on precipitation apportionment, Water discharge from watersheds, Role of water in nutrients cycling.

Succession; An idea of forest succession with focus on Himalayan forest ecosystem.

Attributes of species of different successional stages; recovery measures of disturbed Sites and species selection for disturbed sites in Himalaya.

Major forest types of forest India: Forest classification of India; Forest of Himalaya with particular reference to Sal, Pine and Oak forests.

Global climate changes and forests.

Man and forest: Commercial exploitation of forest, shifting Agriculture; settled agriculture; structure and functioning of Central Himalayan Agroecosystem. Regeneration status of major forest trees acute vs Chronic human disturbance; Shifting cultivation.

SUGGESTED READING:

1. Bir, S.S. and Chatha, G.S. 1988. Forest Vegetation Characteristics of Indian Hills. Today and Tomorrow's Printers & Publ., New Delhi.
2. Misra, R. 1968. Ecology Work Book. Oxford & IBH Publishing Co. New Delhi.
3. Puri, G.S., V.M. Meher-Homji, R.K. Gupta and R.K. Puri (1960). Forest Ecology. Oxford and IBH Pub.Co. Pvt. New Delhi.
4. Singh, J.S. Singh S.P. and Gupta, S.R. 2014. Ecology, Environmental science and Conservation. S. Chand and Company Pvt. Ltd., New Delhi.
5. Waring, R.H. and Schlesinger, W.H. 1985. Forest Ecosystems: Concepts and Management. Academic Press, New York.
6. Troup, R.S. 1921. Silviculture of Indian Trees vol.2. University Press Oxford, U.K.
7. Singh, J.S., S.P. Singh, and S.R. Gupta 2014. Forest of Himalaya: structure, Function and Impact of Man. Gyanodaya Prakashan, Nainital, India.

PAPER 3: PLANT PATHOLOGY

A brief history of plant pathology in India and losses caused by pathogens and pests; types of pathogens, symptoms of different diseases.

Inoculum: Inoculum types, theory of inoculums, survival and longevity of inoculums, inoculums production, potential and density.

Plant microbes interaction: molecular basis of host recognition, pathogenesis: prepenetration, penetration and post penetration events, factors affecting disease development (host factors, environmental factors, virulence susceptibility).

Dissemination of pathogens: Means of dissemination (active and passive dissemination).

Genetics and host parasite interaction: Concept of compatibility and specificity, gene for gene relationship, genetics of resistance, source of resistance, inheritance of resistance in the host.

Enzymes and toxins: Enzymes involved in disease development, toxins and their role in plant health.

Physiology of diseased hosts: Change in physiology processes, e.g., respiration, photosynthesis and disturbance in other metabolic pathways.

Disease resistance: (i) Protection (structural, chemical, absence of nutrients and common antigens)

(ii) Defence (histology defence, chemical- polyphenols, prohibitins, inhabitins, phytoalexins, lectins),

(iii) Genetic resistance: resistant genes, biotechnological approaches for transfer of R- genes into susceptible plant.

Seed pathology: Seed borne pathogens, mechanism of seed infections in field and during storage, transmission of pathogens through seeds, seed health testing methods, market disease of fruits and vegetables.

Disease control: Cultural practices, chemical methods (insecticides, systematic and non-systematic chemical), biological control: Introduction, biological control of insects and pests, use of resistance varieties quarantine.

Brief account, structure, importance, disease cycle and control of the following:

(i) Damping off, (ii) Wilt, (iii) Root rot, stem rot and fruit rot (iv) Mildews (powdery and downy), (v) Rusts, smuts, (vi) Leaf spots and leaf blights.

(ii) General characteristics, importance, disease cycle and control of the following: (i) Bacterial disease, (ii) Viral disease, (iii) Mycoplasma disease.

Suggested readings:

1. Mehrotra, R. S. 1980. Plant pathology. Tata Mc Grow Hill Publishing Co Ltd. New Delhi.
2. Agrios, G. N. 1969. Plant Pathology. Academic Press. New York.
3. Mehrotra, R. S. and Agrawal, A. 2003. Plant Pathology. Tata Mc Grow Hill Publishing Co Ltd. New Delhi.
4. Bouarab, N. K., N. Bissow and F. Daayt. Molecular Plant Microbe Interactions.
5. Narayansamy, P. Pathogens detection and disease diagnosis.
6. Butler, E. J. 1918. Fungi and Diseases in plants. Thacker and Spink and Cooperation. Calcutta.
7. Singh, R. S. 1988. "Plant diseases". Oxford and IBH Publishing Co. Pvt. Ltd. New Delhi.
8. Lucas, J. A. 1988. Plant Pathology and Plant Pathogens. Third edition. Blackwell.

PAPER 4: TAXONOMY OF ANGIOSPERMS

History of different systems of classification (introduction only). Important systems- Bentham and Hooker, Hutchinson, A. Takhtajan, A. Cronquist, Robert Thorne.

A brief account of major contribution made by the following taxonomists: C. Linnaeus, J.D. Hooker, William Roxburgh and Duthie.

Taxonomic evidences- wood anatomy, embryology, palynology, cytotaxonomy, biosystematics, chemotaxonomy and numerical taxonomy.

Cladistics in taxonomy, relevance of taxonomy to conservation.

Some important families: Magnoliaceae, Myrtaceae, Scrophulariaceae, Verbinaceae, Cannabinaceae, Lauranthaceae, Primulaceae, Fagaceae, Orchidaceae, Poaceae.

Local plant diversity and general account of Kumaun flora

Wild and cultivated fruits of Kumaun.

Suggested readings

-Heywood V.H. 1970 Plant taxonomy London.

-Heywood V.H. and D.M. Moore. 1984 Current concept in plant taxonomy. Systematic special volume 25. London.

-Bhattacharya B. and B.M. Joshi 1998. Flowering plants . Taxonomy and phylogeny Norsa publishing house New Delhi.

-Lawrence G.H.M. 1951. Taxonomy of vascular plants. Mac Millan N.York.

-Davis P.H. and Heywood V.H. 1973. Principles of angiosperms taxonomy. Robert E. Kreign Pub. Co. New York.

-Bensen L. 1957. Plant Classification reprint. Oxford & IBH N. Delhi.

-Gaur R.D. 1999. Flora of District Garhwal, N.W. Himalaya Transmedia, Srinagar Garhwal.

-Sambamurty A.V.S.S. Taxonomy of Angiosperms. I.K. International Pvt. Ltd

Practical work

Determination of NPP, Biomass, Leaf Area index, Litter fall, Litter decomposition and Decomposition Rate

Types of inoculum, Dissemination of pathogens, Seed borne pathogens, Biological control of diseases.

Brief account, structure, importance, disease cycle and control of the following

(i) Damping off, (ii) Wilt, (iii) Root rot, stem rot and fruit rot (iv) Mildews (powdery and downy), (v) Rusts, smuts, (vi) Leaf spots and leaf blights.

(ii) General characteristics, importance, disease cycle and control of the following: (i) Bacterial disease, (ii) Viral disease, (iii) Mycoplasma disease.

Identification of some important families: Magnoliaceae, Myrtaceae, Scrophulariaceae, Verbinaceae, Cannabinaceae, Lauranthaceae, Primulaceae, Fagaceae, Orchidaceae, Poaceae.

Local plant diversity

Wild and cultivated plants of Kumaun.