

**DEPARTMENT OF BOTANY**  
**KUMAUN UNIVERSITY, NAINITAL**

**‘FINAL DRAFT SYLLABUS’**  
**FOR**  
**M.Sc. BOTANY**

**[AS PER NATIONAL EDUCATION POLICY-2020]**

**FACULTY OF SCIENCE**

**2023**

KUN

**Prepared by:**

Prof. Surendra Singh Bargali (Head)

Prof. Yaswant Singh Rawat

Prof. Lalit Mohan Tewari

Dr. Kiran Bargali

Dr. Sushma Tamta

Dr. Neelu Lodhiyal

Dr. Anil Kumar Bisht

Dr. Kapil Khulbe

Dr. Harsh Kumar Chauhan

Dr. Prabha Pant

Dr. Naveen Chandra Pandey

Dr. Hem Chandra Joshi

Dr. Himani Karki

**Department of Botany, D.S.B. Campus,**

**Kumaun University, Nainital -263001**

**External Experts (NEP-2023 Workshop)**

**Prof. Gulshan Kumar Dhingra**

Head, Department of Botany  
Shri Dev Suman Uttarakhand University  
Chamba, Tehri Garhwal-249145

**Dr. Dhani Arya**

Head, Department of Botany  
Soban Singh Jeena University  
Almora-263601

**External Experts (BOS-2022)**

**Prof. N.K. Dubey**, Banaras Hindu University, Varanasi

**Prof. C.M. Sharma**, H.N.B. Garhwal University, Srinagar

**Prof. P.L. Uniyal**, University of Delhi, New Delhi

**MEMBERS PRESENT IN BOS (29.06.2022)**

**Prof. S.S. Bargali**

D.S.B. Campus, Kumaun University, Nainital

**Prof. N.K. Dubey**

Banaras Hindu University, Varanasi

**Prof. C.M. Sharma**

H.N.B. Garhwal University, Srinagar

**Prof. P.L. Uniyal**

University of Delhi, New Delhi

**Prof. LM. Tewari**

D.S.B. Campus, Kumaun University, Nainital

**Prof. Kiran Bargali**

D.S.B. Campus, Kumaun University, Nainital

**Prof. Anjala Durgapal**

Government Degree College, Nanakmatta

**Dr. A.K. Paliwal**

Government P.G. College, Rudrapur

**Dr. S.S. Maurya**

P.N.G P.G. College, Ramnagar

**Dr. Prem Prakash**

M.B.P.G. College, Haldwani

Course structure of M.Sc. Botany

| Year | Semester | Course Code   | Name of Course                              | Type of course | Total Credits | Marks (scaled) |
|------|----------|---------------|---|----------------|---------------|----------------|
| 4    | VII      | BOT/I/CC/01   | Microbiology                                | CC             | 4             | 100            |
|      |          | BOT/I/CC/02   | Phycology                                   | CC             | 4             | 100            |
|      |          | BOT/I/CC/03   | Mycology                                    | CC             | 4             | 100            |
|      |          | BOT/I/CC/04   | Bryophytes and Pteridophytes                | CC             | 4             | 100            |
|      |          | BOT/I/CC/05   | Lab/Practical based on CC/01 to CC/04       | CC             | 4             | 200            |
|      |          | BOT/I/EC/01   | Industrial training/Survey/Research project | EC             | 4             | 100            |
|      | VIII     | BOT/II/CC/06  | Gymnosperms and Paleobotany                 | CC             | 4             | 100            |
|      |          | BOT/II/CC/07  | Diversity and Taxonomy of Angiosperms       | CC             | 4             | 100            |
|      |          | BOT/II/CC/08  | Plant Development and Reproductive Biology  | CC             | 4             | 100            |
|      |          | BOT/II/CC/09  | Cytogenetics and Plant Breeding             | CC             | 4             | 100            |
|      |          | BOT/II/CC/10  | Lab/Practical based on CC/05 to CC/08       | CC             | 4             | 200            |
|      |          | BOT/II/EC/02  | Industrial training/Survey/Research project | EC             | 4             | 100            |
|      | IX       | BOT/III/CC/11 | Plant Ecology                               | CC             | 4             | 100            |
|      |          | BOT/III/CC/12 | Plant Resource Utilization and Conservation | CC             | 4             | 100            |

|   |   |               |  |  |    |     |     |
|---|---|---------------|--|--|----|-----|-----|
| 5 |   | BOT/III/CC/13 | Biotechnology                                | CC   | 4  | 100 |     |
|   |   | BOT/III/CC/14 | Plant Physiology                             | CC   | 4  | 100 |     |
|   |   | BOT/III/CC/15 | Lab/ practical based on CC/09 to CC/12       | CC   | 4  | 200 |     |
|   |   | BOT/III/EC/03 | Industrial training/Survey/ Research project | EC   | 4  | 100 |     |
|   | X |               | BOT/IV/CC/16                                 | Biochemistry   | CC | 4   | 100 |
|   |   |               | BOT/IV/CC/17                                 | Cell Biology   | CC | 4   | 100 |
|   |   |               | BOT/IV/EC/18 (i)*                            | Forest Ecology   | EC | 4   | 100 |
|   |   |               | BOT/IV/EC/18(ii)*                            | Plant Pathology  | EC | 4   | 100 |
|   |   |               | BOT/IV/EC/18(iii)*                           | Taxonomy of Angiosperms  | EC | 4   | 100 |
|   |   |               | BOT/IV/EC/18(iv)*                            | Ethnobotany, Indigenous knowledge and Intellectual Property Rights | EC | 4   | 100 |
|   |   |               | BOT/IV/EC/18(v)*                             | Bryology   | EC | 4   | 100 |
|   |   |               | BOT/IV/EC/18(vi)*                            | Lichenology  | EC | 4   | 100 |
|   |   |               | BOT/IV/EC/19                                 | Lab based on Final Semester CC and EC courses                      | CC | 4   | 200 |
|   |   | BOT/IV/EC/04  | Industrial training/Survey/ Research project | EC   | 4  | 100 |     |

CC= Core course; EC= Elective course; \*Two elective courses are to be opted.

 19-06-2023  
 19/06/2023  
 19.6.2023  
 19-06-2023  
 19.06.2023  
 19/6/2023  
 19/6/2023  
 Faculty of Science  
 Kumaun University  
 Nainital  
  
 Professor & Head  
 Department of Botany  
 D.S.B. Campus  
 Kumaun University, Nainital - 2630  
 Uttarakhand (India)

### Minor Elective Courses in Botany\*

| Year | Semester   | Course Code | Name of Course                     | Type of course | Total Credits | Marks Scaled |
|------|------------|-------------|------------------------------------|----------------|---------------|--------------|
| 4    | VII / VIII | BOT/4/ME/01 | Plant Cell Structure and Functions | ME             | 4             | 100          |
|      |            | BOT/4/ME/02 | Applied Microbiology               | ME             | 4             | 100          |
|      |            | BOT/4/ME/03 | Global Climate Change              | ME             | 4             | 100          |
|      |            | BOT/4/ME/04 | Medicinal Plants of Uttarakhand    | ME             | 4             | 100          |

- One minor elective course to be opted in semester VII or VIII

### M. Sc. Botany

#### Programme Outcomes (POs):

The M.Sc. - Botany programme is designed to equip students with essential knowledge and technical skills of plants in a holistic manner. Students would be trained in all areas of plant biology using a unique combination of core and elective papers with significant inter-disciplinary components. Students would be exposed to progressive technologies that are currently used in the study of plant life forms, their evolution and interactions with other organisms within the ecosystem. Students would also become aware of the social and environmental significance of plants and their relevance to the national economy.

#### Programme specific outcomes (PSO's)

**PSO1.** Students completing the course will be able to understand different aspects of Botany such as Microbiology, Phycology, Mycology, Bryophytes and Pteridophytes.

**PSO2.** The student completing the course will understand the diversity and phylogeny of the Gymnosperms, Taxonomy of Angiosperms, Cell and Molecular Biology and concepts and processes in Plant Anatomy, Developmental Biology.

**PSO3.** The students completing the course will be able to identify various life forms of plants, design and execute experiments related to basic studies on ecology, physiology, biochemistry, plant biotechnology, recombinant DNA technology, proteomics and transgenic technology, use of plants as industrial resources or as human livelihood support system.

**PSO4.** The students completing the course will be capable of executing short research projects incorporating various tools and techniques in any of the basic specializations of Plant Sciences under supervision.

### **DETAILED SYLLABUS MASTER OF SCIENCE**

#### **Semester-VII**

#### **BOT/I/CC/01: Paper I: Microbiology: Bacteria, Virus and Lichens**

**(Credits: 4) Max Marks 100; 75 External Exam+ 25 internal assessment)**

**Course outcomes:** After the completion of the course the students will be able to:

1. Understand the occurrence, general characters, types, reproduction and life cycles of the major microbial groups and their role in food, clinical and industrial microbiology.
2. Apply practical skills in basic microbiological techniques.
3. Evaluate the classificatory approaches and advances in bacterial, viral and lichen taxonomies.

| <b>Unit</b> | <b>Topic</b>  | <b>Total No. of lecturers/hrs (48)</b> |
|-------------|---|--|
| <b>1</b>    | 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, endophytic microorganisms.  | <b>12</b>                              |
| <b>2</b>    | 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. | <b>12</b>                              |
| <b>3</b>    | 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  | <b>12</b>                              |

|          |   |           |
|----------|---|-----------|
|          | organization and multiplication, bacteriophage therapy, Corona virus.   |           |
| <b>4</b> | 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 | <b>12</b> |

#### Suggested readings

- Tortora, G. J., Funke, B.R. and Case C.L.(2021). Microbiology: An Introduction, Pearson Benjamin Cummings, U.S.A. 13th edition.
- Madigan, Bender, Buckley, Sattley, Stahl. (2019). Brock Biology of Microorganisms. Pearson. 15th edition.
- Marjorie, Kelly. and Cowan, Heidi Smith. (2017). Microbiology: A Systems Approach. McGraw Hil INew York, 5th edition.
- Kathleen Park, Talaro and Barry Chess. (2017). Foundations in Microbiology. Mc Graw Hill New York, 10th edition.
- Willey, Joanne, Sherwood, Linda., Woolverton, Christopher J.(2017). Prescott's Microbiology. McGraw Hill New York, 11th edition.
- Mukherjee, K.G. and Singh V.P (1997). Frontiers in Applied Microbiology. Rastogi Publ. Meerut.
- Power, C.B. and Daginawala H.F. (1996). General Microbiology. Vol 2. Himalaya Pub. House, New Delhi.
- Kaushik, P. (1996). Introductory Microbiology. Emkay Publ, Delhi.
- Pelczar, M.J., Chan, ECS and Kreig, N.R. (1993). Microbiology. McGraw Hill, New York. Fifth Edition.
- Alexander, M. (1991). Microbial Ecology. John Wiley and Sons. New York.
- Doelle, H.W. and C.G, Heden (1986). Applied Microbiology, Kulwer Academic Press, London.
- Miller, B.M. and W. Litsky (1976). Industrial Microbiology. Mc Graw Hill New York.
- Norris, J.R. and Ribbons D.W. (1970). Methods in Microbiology. Academic Press, London.

#### **BOT/I/CC/02: Paper II: Phycology**

**(Credits: 4, Max Marks 100; 75 External Exam+ 25 internal assessment)**

**Course outcomes:** After the completion of the course the students will be able to:

1. Understand the contributions of famous Indian phycologists and centers of Algal Research in India.
2. Understand the classificatory approaches and advances in algal taxonomy.
3. Understand the general features of algae and its different groups and their representative genera.
4. Study their ecological and economic importance.



| Unit | Topics   | Total No. of lecturers/hrs (48) |
|------|--|---------------------------------|
| 1    | 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; Economic importance of algae.   | 12                              |
| 2    | 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.<br>Ecology of Algae: Diversified habitats of Algae, Eutrophication, water blooms and phytoplanktons.  | 12                              |
| 3    | A detailed study of following orders with given genera:<br>Cyanophyta: Chroococcales ( <i>Chroococcus</i> , <i>Microcystis</i> ), Oscillatoriales ( <i>Oscillatoria</i> and <i>Lyngbya</i> ), Nostocales ( <i>Anabaena</i> , <i>Spirulina</i> ), Rivulariales ( <i>Rivularia</i> );<br>Chlorophyta: Chlamydomonadales ( <i>Haematococcus</i> ), Volvocales ( <i>Pandorina</i> , <i>Eudorina</i> ), Chlorococcales ( <i>Chlorella</i> , <i>Hydrodictyon</i> ), Cladophorales ( <i>Cladophora</i> ), Chaetophorales ( <i>Coleochaete</i> , <i>Fritschiella</i> ), Zygnemetales ( <i>Zygnema</i> ), Charophyta: Charales ( <i>Chara</i> ) | 12                              |
| 4    | A detailed study of following orders with given genera:<br>Xanthophyta- Heterosiphonales ( <i>Botrydium</i> , <i>Vaucheria</i> )<br>Bacillariophyta- Pennales and Centrales (Pinnate diatoms and centric diatoms)<br>Phaeophyta- Ectocarpales ( <i>Ectocarpus</i> ), Laminariales ( <i>Laminaria</i> ), Fucales ( <i>Sargassum</i> , <i>Fucus</i> )<br>Rhodophyta- Gigartinales ( <i>Gracillaria</i> ), Gelidiales ( <i>Gelidium</i> ), Ceramiales ( <i>Polysiphonia</i> ), Nemalionales ( <i>Betrachospermum</i> ).   | 12                              |

#### Suggested readings

- Robert Edward Lee.(2018). Phycology. Cambridge University Press, U.K. 5th edition.
- Bellinger, E. G. and Sigeo, D. C. (2015). Freshwater Algae: Identification, Enumeration and Use as Bioindicators. Wiley-Blackwell. 2nd edition.
- Barsanti, Laura (2014). Algae: Anatomy, Biochemistry, and Biotechnology. CRC Press, U.K. 2<sup>nd</sup>

edition.

- Kara Rogers. (2011). Fungi, Algae, and Protists. Rosen Educational Services.
- Sharma, O. P. (2011). Algae. Tata McGraw Hill Education Private Limited, U.K. 1st edition.
- Lee R.W. (2008). Phycology. Colorado State University.
- Kumar, H.D. (1999). Introductory Phycology. Affiliated East-West Press Ltd. N. Delhi.
- Morris, I. (1986). An Introduction of Algae. Cambridge University Press, U.K.
- Prescott, G.W. (1984). Algae: A review, Bishan Singh Mahendra Pal Singh, Dehradun.
- Round, F.E. (1984). Ecology of Algae. Academic Press, London.
- Desikachary, T.V. (1984). Cyanophyta. ICAR, New Delhi.
- Fritsch, F.E. (1979). The structure and reproduction of Algae. Vol.1 and 2. Bishan Singh Mahendra Pal Singh. Dehradun.
- Trainer, F.R. (1978). Introductory Phycology. John Wiley and Sons. Inc.
- Tilden, J.F. (1968). The algae and their life relations. Hafner Publishing Co. New York.
- Smith G.M. (1951). Manual of Phycology, Waltham, Mass, U.S.A, Chronica Botanica Company.

### **BOT/I/CC/03: Paper III: Mycology**

**(Credits: 4, Max Marks 100; 75 External Exam+ 25 internal assessment)**

**Course outcomes:** After the completion of the course the students will be able to:

1. Understand the general characters, structure, nutrition, reproduction and the principles on classifications of Fungi.
2. Study fungal associations and fungal physiology.
3. Understand the economic and pathological importance of fungi.
4. Understand the occurrence, general characters, types, reproduction and life cycles of the major fungal groups.

| <b>Unit</b> | <b>Topic</b>  | <b>Total No. of lecturers/hrs (48)</b> |
|-------------|---|--|
| <b>1</b>    | General characteristics (Somatic structures, cell wall composition and nutrition in fungi), Reproduction in Fungi (vegetative, asexual and sexual); Heterothallism and Heterokaryosis, Parasexual cycle, Mycorrhiza | <b>12</b>                              |
| <b>2</b>    | Recent trends in classification of fungi, phylogeny of Fungi, Importance of Fungi   | <b>12</b>                              |

|          |  |           |
|----------|--|-----------|
| <b>3</b> | <p>General account of the following classes of fungi with emphasis on the given genera:</p> <p>Myxomycotina: <i>Stemonitis, Physarum</i></p> <p>Mastigomycotina: <i>Allomyces, Monoblepharis</i></p> <p>Oomycotina: <i>Saprolegnia, Pythium, Phytophthora, Sclerospora</i></p> <p>Zygomycotina: <i>Mucor, Pilobolus, Entomophthora</i></p> | <b>12</b> |
| <b>4</b> | <p>Ascomycotina: <i>Saccharomyces, Aspergillus, Talaromyces (Penicillium), Taphrina, Phyllactinia, Peziza, Cordiceps, Claviceps.</i></p> <p>Basidiomycotina: <i>Puccinia, Ustilago, Geastrum, Fomes, Uromyces.</i></p> <p>Deuteromycotina: <i>Fusarium, Cercospora, Pyricularia, Colletotrichum, Trichoderma, Helminthosporium</i></p>     | <b>12</b> |

#### Suggested readings

- Kavanagh, Kevin. (2018). Fungi: Biology and Applications. Wiley-Blackwell. 3rd edition.
- Bryce Kendrick. (2017). The Fifth Kingdom: An Introduction to Mycology. Hackett Publishing. 4th Edition.
- Sati, S.C. and Belwal, M. (2012). Microbes Diversity and Biotechnology. Daya Publication.
- John Webster and Roland Weber. (2007). Introduction to Fungi. Cambridge University Press. 3rd Edition.
- Mehrotra, R.S. and K.R. Aneja. (1999). An Introduction to Mycology. New Age International Publisher.
- Alexopoulos, C.J. and Mims C.W. (1995). Introductory Mycology. John Wiley and Sons. New York. Fourth Edition.
- Webster, J. (1985). Introduction to Fungi. Cambridge University Press. New York.
- Ainsworth, G.C. (1976). Introduction to the history of Mycology. Academic Press. New York.

#### **BOT/I/CC/04: Paper IV: Bryophytes and Pteridophytes** (Credits: 4, Max Marks 100; 75 External Exam+ 25 internal assessment)

**Course outcomes:** After the completion of the course the students will be able to:

1. Understand the origin, diversity and evolution of Bryophytes and Pteridophytes.
2. Understand the different classificatory systems of Bryophytes and Pteridophytes.
3. Understand the general characters and the structure of the plant body of the types of Bryophytes and Pteridophytes mentioned in the syllabus.
4. Study the ecological and economic Importance of bryophytes and pteridophytes that will help to understand their role in ecosystem functioning.

| Unit | Topic   | Total No. of lecturers/ hrs (48) |
|------|---|----------------------------------|
| 1    | Evolutionary Trends in Bryophytes; Bryology in India; General idea about morphology, cytology and reproduction in Bryophytes; Ecological and Economic Importance of bryophytes, Role of bryophytes in monitoring mineral deposition and as an indicator of air pollution; Modern system of Classification of Bryophytes, Experimental studies in Bryophytes   | 12                               |
| 2    | Salient features of the following genera:<br><i>Sphaerocarpos</i><br><i>Marchantia</i> , <i>Lunularia</i> , <i>Plagiochasma</i> , <i>Reboulia</i> , <i>Asterella</i> ,<br><i>Cryptomitrium</i> ,<br><i>Targionia</i> , <i>Conocephalum</i> , <i>Cyathodium</i><br><i>Frullania</i> , <i>Porella</i> , <i>Radula</i><br><i>Pellia</i> , <i>Sewardiella</i> , <i>Metzgeria</i> , <i>Riccardia</i><br><i>Haplomitrium</i><br><i>Anthoceros</i> , <i>Foilioceros</i> , <i>Megaceros</i> , <i>Phaeoceros</i> ,<br><i>Notothylas</i><br><i>Sphagnum</i> , <i>Andreaea</i><br><i>Takakia</i> , <i>Buxbaumia</i> , <i>Polytrichum</i> | 12                               |
| 3    | A brief account of origin of pteridophytes, Pteridophyte Phylogeny Group classification (PPG), Heterospory and seed habit, telome theory, apogamy, apospory and apomixes. Salient features of early land plants- <i>Rhynia</i> and <i>Horneophyton</i>  | 12                               |
| 4    | Salient features of the following genera:<br><i>Lepidodendron</i> , <i>Lepidocarpon</i><br><i>Lycopodium</i><br><i>Isoetes</i><br><i>Selaginella</i><br><i>Hyenia</i><br><i>Sphenophyllum</i><br><i>Calamites</i><br><i>Equisetum</i><br><i>Psilotum</i><br><i>Ophioglossum</i><br><i>Marattia</i><br><i>Osmunda</i><br><i>Azolla</i> , <i>Marsilea</i><br><i>Adiantum</i>  | 12                               |

### Suggested readings

- Sharma, O.P. (2017). Bryophyta. McGraw Hill Education. India
- The Pteridophyte Phylogeny Group (PPG Classification) (2016): A community –derived classification for extant lycophytes and ferns. *Journal of Systematics and Evolution*. 54(6): 563-603.  
Doi:10.1111/jse.12229
- Alain Vanderpoorten, Bernard Goffinet. (2009). Introduction to Bryophytes. McGraw Hill Education India.
- Rashid, A. (1998). An Introduction to Bryophyta: diversity, development and differentiation. Vikas Publishing House.
- Parihar, N.S. (1996). Biology and Morphology of Pteridophytes. Central Book Depot Allahabad.
- Parihar, N.S. (1991). Bryophyta. Central Book Depot, Allahabad.
- Udar, R. (1986). Fifty years of Bryology in India. Golden Jubilee Series. IBS, New Delhi.
- Puri, P. (1980). Bryophytes. Atma Ram & Sons, Delhi.
- Pandey, B.P. (1979). College Botany Vol II Including Pteridophyta, Gymnosperms and Paleobotany. . S. Chand and Company Ltd. Ramnagar, New Delhi.
- Sporne, K.R. (1975). The Morphology of Pteridophytes. HarperCollins Publishers Ltd; Revised edition.
- Smith, G.M. (1955). Cryptogamic Botany. Vol. I and II. Tata McGraw Hill, New Delhi.

**Practical/ Lab course (BOT/I/CC/05: Based on the CC/01 to CC/04 papers) Semester VIII**

### **BOT/II/CC/06: Paper V: Gymnosperms and Paleobotany** (Credits 4, Max Marks 100; 75 External Exam+ 25 internal assessment)

**Course outcomes:** After the completion of the course the students will be able to:

1. Understand the general characters, distribution and significance of Gymnosperms.
2. Understand the morphology, anatomy and reproduction of common Gymnosperms.
3. Remember the evolutionary eras and periods.
4. Understand the techniques and process of fossilization.

| <b>Unit</b> | <b>Topic</b>   | <b>Total No. of lecturers/hrs (48)</b> |
|-------------|--|--|
| <b>1</b>    | Introduction: History, classification, distribution and evolution of gymnosperms, economic importance of Gymnosperms, seed trapping and regeneration potential of Gymnosperms<br>Brief account of the families of Pteridospermales (Lyginopteridaceae, Medullosaceae, Caytoniaceae and Glossopteridaceae). | <b>12</b>                              |
| <b>2</b>    | General account of Cycadeoideales<br>General account of Cordaitales<br>General account of Pentoxylales<br>Morphology, anatomy and reproduction in Cycadales  | <b>12</b>                              |
| <b>3</b>    | Morphology, anatomy and reproduction in Ginkgoales<br>Morphology, anatomy and reproduction in Coniferales<br>General account of Ephedrales<br>General account of Welwitschiales<br>General account of Gnetales   | <b>16</b>                              |
| <b>4</b>    | Preservation of fossil plants<br>Types of fossils and modes of formation of different kinds of fossils; Gondwana flora   | <b>8</b>                               |

#### **Suggested reading**

- Kaur, Inderdeep and Uniyal, P.L.(2019). Textbook of Gymnosperms. Daya Publication, New Delhi.
- Biswas, Chhaya, Johri, B. M. (2014). The Gymnosperms. Springer Berlin.
- Vashishta, P.C., Sinha, A.K. and Kumar, A. (2012). Botany for degree students. Gymnosperm. S. Chand and Company Ltd. Ramnagar, New Delhi.
- Pant, D.D. and Osborne, R. and Birbal Sahni. (2002). An introduction to gymnosperms, cycas, and cycadales. Birbal Sahni Institute of Palaeobotany.
- Singh, S.K. (2002). Gymnosperms and paleobotany. Campus Book International.
- Bhatnagar, S.P. and Moitra, A. (1996). Gymnosperms New Age International, Pvt Ltd (P) New Delhi.
- Chamberlain, C.J. (1980) Gymnosperms Structure and Evolution. CBS Publishers and Distributors.
- Pandey, B.P. (1979). College Botany Vol II Including Pteridophyta, Gymnosperms and Paleobotany. S. Chand and Company Ltd. Ramnagar, New Delhi.

**BOT/II/CC/07: Paper VI: Diversity and Taxonomy of Angiosperms**  
**(Credits: 4, Max Marks 100; 75 External Exam+ 25 internal assessment)**

**Course outcomes:** After the completion of the course the students will be able to

1. Understand about the diversity and classification of plants.
2. Understands description, identification, nomenclature and classification of plants.
3. Study the types of inflorescence and their origin.
4. Understand the concepts of phytogeography, endemism, plant migration, invasions and introduction.
5. Study the characteristic features and economic importance of some important families.

| <b>Unit</b> | <b>Topic</b>  | <b>Total No. of lecturers/hrs (48)</b> |
|-------------|---|--|
| <b>1</b>    | Important system of classification Bentham & Hooker, J. Hutchinson and A. Takhtajan, Angiosperm Phylogeny Group (APG IV) classification and their merits and demerits, Salient Features of International Code of Botanical Nomenclature (ICN), Elementary idea of molecular taxonomy.<br>The species concept: Taxonomic Hierarchy, species, genus, family and other categories. Principles used in assessing relationships, delimitation of taxa and attribution of rank. | <b>12</b>                              |
| <b>2</b>    | Origin of intra-population variation. Population and the environment, ecads, ecotypes, evolution and differentiation of species.<br>Plant exploration in India with special reference to Uttarakhand.<br>Origin and evolution of angiosperms, fossils, Type of inflorescence and their origin.  | <b>12</b>                              |
| <b>3</b>    | Taxonomic tools, herbarium, flora, histological, cytological, phytochemical, serological, biochemical, and molecular techniques.<br>Concepts of phytogeography, endemism, plant migration, invasions and introduction.  | <b>12</b>                              |
| <b>4</b>    | Distinguishing features of the following families and their economic importance: Ranunculaceae, Violaceae, Rutaceae, Fabaceae, Rosaceae, Apiaceae, Rubiaceae, Asteraceae, Apocynaceae, Solanaceae, Lamiaceae, Euphorbiaceae, Orchidaceae, Liliaceae, Poaceae.   | <b>12</b>                              |

### Suggested readings

- Angiosperm Phylogeny Group (APG-2016). An update of the Angiosperm Phylogeny Group Classification for the orders and families of flowering plants: APG IV. Botanical Journal of the Linnaean Society 181: 1-20.
- Sharma O.P. (2013). Plant Taxonomy. Mc Graw hill India.
- Saxena N.B. and Saxena S. (2012). Plant Taxonomy Pragati Prakashan.
- Sambamurty, A.V.S.S. (2010). Taxonomy of Angiosperms. I.K. International Pvt. Ltd.
- Gaur, R.D. (1999). Flora of District Garhwal, N.W. Himalaya Transmedia, Srinagar Garhwal.
- Davis and Heywood, V.H. (1973). Principles of angiosperms taxonomy.
- Bensen, L. (1957). Plant Classification. Reprint Oxford & IBH. N. Delhi.

### **BOT/II/CC/08: Paper VII: Plant Development and Reproductive Biology**

**(Credits: 4, Max Marks 100; 75 External Exam+ 25 internal assessment)**

**Course outcomes:** After the completion of the course the students will be able to:

1. Understand the morphological characteristics of flower.
2. Study the fundamental concepts of shoot, leaf and root development.
3. Understand various stages of development of plants.
4. Understand the developmental biology of male and female gametophyte, pollen-pistil interaction.
5. Study the basic idea of embryogenesis and seed development process, apomixes and polyembryony.

| Unit | Topic   | Total No. of lecturers/ hrs (48) |
|------|---|----------------------------------|
| 1    | 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).  | 12                               |
| 2    | Shoot development: Organization of the shoot apical meristem (SAM): control of cell division and tissue differentiation especially xylem and phloem: secretory ducts and Laticifers.<br>Leaf growth and differentiation, structural development and classification of stomata and trichomes.<br>Root Development: Organization of root apical meristem (RAM), vascular tissues differentiation, lateral root, root hairs, ABCD model of flower, Florigen pathway. | 12                               |
| 3    | Male gametophyte: Structure of anthers, microsporogenesis, role of tapetum, pollen development, pollen germination, pollen tube growth and guidance, pollen allergy.<br>Female gametophyte: Ovule development, megasporogenesis, development and organization of the embryo sac, structure of the embryo sac cells.   | 12                               |



|          |  |           |
|----------|--|-----------|
| <b>4</b> | <p>Pollination, pollen-pistil interaction and fertilization: pollination mechanism and vectors, sporophytic and gemetophytic self-incompatibility, double fertilization.</p> <p>Seed development and fruit growth: Endosperm development during early maturation and desiccation stages: embryogenesis, cell lineages during late embryo development, polyembryony, apomixis.</p> <p>Latent life- dormancy: Importance and types of dormancy, seed dormancy, bud dormancy.</p> | <b>12</b> |
|----------|--|-----------|

#### **Suggested readings**

- Bhatnagar S.P, Dantu, P.K. Bhojwai S.S. (2018). The embryology of Angiosperms. Vikas Publ. House. New Delhi.
- Lalit M. Srivastava. (2002). Plant Growth and Development. Hormones and Environment. Academic Press. 1<sup>st</sup> Edition.
- Raghavan V. (1999). Developmental biology of flowering plants. Springer Velag. New York.
- Howell, S.H. (1998). Molecular genetics of plant Development. Cambridge Univ. Press.
- Raghwan, (1997). Molecular embryology of flowering plants. Cambridge Univ. Press. Cambridge.
- Shivanna, K.R. and Sawhney, V.K. (1997). Pollen Biotechnology for Crop Production and Improvements. Cambridge Univ. Press.
- Fonkot, De. (1994). Plant growth and Development. A molecular approach. Academic Press. San Diego.
- Lyndon. R.F. (1990). Plant Development. The Cellular Basis. Unnin Hyman. London.
- Leins, P., Tucker, S.C. and Endress, P.K. (1988). Aspects of floral development. J. Cramer. Germany.

#### **BOT/II/CC/09: Paper VIII: Cytogenetics and Plant Breeding**

**(Credits 4, Max Marks 100; 75 External Exam+ 25 internal assessment)**

**Course outcomes:** After the completion of the course the students will be able to

1. Apply the concepts of Mendelian genetics to solve problems on linkage, crossing over and gene mapping.
2. Analyze human pedigree and apply the principles of population genetics to work out problems on genotype frequency and Hardy-Weinberg equilibrium. Understand the Chromosomal aberrations and their role in genome evolution with special reference to crop plants.
3. Understand modern breeding methods in improving agricultural crop varieties.
4. Understand the process of cell cycle its regulation and the mechanism of apoptosis.

| Unit | Topic  | Total No. of lecturers/ hrs (48) |
|------|--|----------------------------------|
| 1    | 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 - gene pool, gene frequency, Hardy-Weinberg law. | 12                               |
| 2    | Structural and numerical alterations 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 uses, chromosome mapping of diploid and polyploidy species, evolution of major crop plants (wheat and rice), Apomixes, Hybridization .  | 12                               |
| 3    | Mutation: spontaneous and induced mutation; physical and 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.  | 12                               |
| 4    | Chromosome structure: packaging 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<br>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.   | 12                               |

#### Suggested readings

- Lodish, H., Berk, A., Zipursky, S.L. Maztsudaira, P., Baltimore, Dand Darnell, I. (2016). Molecular Cell Biology (8<sup>th</sup> Edition). W.H. Freeman and Co., New York, USA.
- Alberts, B., Bray,D., Lewis, J., Raff, M., Roberts, K. and Watson, J.D. (2014). Molecular Biology of the Cell. Garland Publishing Inc., New York.6<sup>th</sup> edition.
- Watson, J.D. (2013).Molecular Biology of the Genes, Benjamin.7<sup>th</sup> Edition.
- Buchanan, B.B., Gruissem, W. and Jones, R.L. (2000). Biochemistry and Molecular Biology of Plants. American Society of Plant Physiologists, Maryland, USA.
- De, D.N. (2000). Plant Cell Vacuoles: An Introduction. CSIRO Publication, Collingwood, Australia.
- Lewin, B. (2000). Genes VII. Oxford University Press, New York.

- Atherly, A.G., Girton, J.R. and McDonald, J.F. (1999). The Science of Genetics. Saunders College Publishing, Fort Worth, USA.
- Gupta, P.K. (1998). Cytogenetics. Rastogi Publications, Meerut.
- Hartl, D.L. and Jones, E.W. (1998). Genetics: Principles and Analysis (4<sup>th</sup> Edition). Jones and Bartlett Publishers, Massachusetts, USA.
- Malacinski G.M.D. and Freifelder, D. (1998). Essentials of Molecular Biology (3<sup>rd</sup> Edition). Jones and Bartlett Publishers, Inc. London.
- Kleinsmith, L.J. and Kish, V.M. (1995). Principles of Cell and Molecular Biology (2<sup>nd</sup> Edition). Harper Collins College Publishers, New York, USA.
- Wolfe, S.L. (1993). Molecular and Cellular Biology. Wadsworth Publishing Co. California.
- Stent, G.S. (1986). Molecular genetics. Bishen Singh Mahendra Pal Singh, Dehradun.
- Busch, C.R. and Rothblum, L. (1982). Volume X. The Cell Nucleus r DNA Part A. Academic Press.
- Barry, J.M. and Barry. B.M. (1973). Molecular Biology, Prentice Hall of India. New Delhi.

**Practical/ Lab course BOT/II/CC/10: Based on the CC/05 to CC/08 papers**

**Minor Elective Courses in Botany**

**BOT/4/ME4 /01: Paper I: Plant Cell Structure and Functions  
(Credits 4, Max Marks 100; 75 External Exam+ 25 internal assessment)**

**Course outcomes:** After the completion of the course the students will be able to:

1. Understand the plant cell structure and its function.
2. Understand the various cell components and the general principles in cell communication and interaction.
3. Study the structure and genome organization of chloroplast and mitochondria.

| Unit | Topic   | Total No. of lecturers/ hrs (48) |
|------|---|----------------------------------|
| 1    | Principles of microscopy, structural organization of the plant cell and its chemical foundation, Cell wall structure and function | 12                               |
| 2    | Plasma membrane, Cytoskeleton, organization and role of microtubules and microfilaments   | 12                               |
| 3    | Structure and functions of endoplasmic reticulum, golgi apparatus, ribosomes and protein synthesis                                | 12                               |
| 4    | Structure and genome organization of chloroplast and mitochondria.  | 12                               |

**BOT/4/ME/02: Paper II: Applied microbiology**

**(Credits 4, Max Marks 100; 75 External Exam+ 25 internal assessment)**

**Course outcomes:** After the completion of the course the students will be able to:

1. Understand the major fields, scope and importance of applied microbiology.
2. Study the medical, aquatic, food, soil, industrial and geochemical microbiology.
3. Understand the mushroom cultivation and single cell production.

| Unit | Topic   | Total No. of lecturers/ hrs (48) |
|------|---|----------------------------------|
| 1    | Microbiology and its scope: microorganisms in the living World: Group of microorganisms. Occurrence and distribution of microorganisms in Nature. Major fields of applied microbiology. | 12                               |
| 2    | Medical microbiology, Aquatic microbiology: Water purification, microbiological examination; Biological degradation of waste; Aero microbiology.  | 12                               |
| 3    | Food microbiology. Soil Microbiology  | 12                               |
| 4    | Industrial microbiology. Geochemical microbiology. Mushroom cultivation and Production of single cell protein.  | 12                               |

### Suggested readings

- Tortora, G.J., Funke, B.R. and Case C.L. (2021). Microbiology: An Introduction, Pearson Benjamin Cummings, U.S.A. 13th edition.
- Gadd, G. and Sariaslani S. (2020). Advances in Applied Microbiology, Elsevier.
- Willey, Joanne, Sherwood, Linda., Woolverton, Christopher J. (2017). Prescott's Microbiology. McGraw Hill New York, 11th edition.
- Saxena, S. (2015). Applied Microbiology, Springer.
- Pelczar, M.J., Chan, ECS and Kreig, N.R. (1993). Microbiology. McGraw Hill, New York. Fifth Edition.

### BOT/4/ME/03: Global Climate Change

(Credits 4, Max Marks 100; 75 External Exam+ 25 internal assessment)

**Course outcomes:** After the completion of the course the students will be able to:

1. Understand the global climate changes and global warming.
2. Learn about the measures being taken for the mitigation of climate changes.

| Unit | Topic  | Total No. of lecturers/ hrs (48) |
|------|--|----------------------------------|
| 1    | General concept of Global climate change; Greenhouse effect; Greenhouse gasses; Carbon foot print, Carbon sequestration.   | 12                               |
| 2    | Impact of global warming and climate change, weather extremes, ecosystem disruption, human health, sea level rise and impact on forests                          | 12                               |
| 3    | International initiative for mitigating global changes; Inter governmental panel on climate change (IPCC); United Nation Frame work convention on Climate change | 12                               |
| 4    | Kyoto protocol; Montreal protocol; Paris Pact; India's initiatives for mitigating climate change.  | 12                               |

### Suggested readings

- Singh, S., Singh, P., Rangabhashiyam, S. and Srivastava, K. K. (2021). Global Climate Change, Elsevier.

- Singh, J.S. Singh S.P. and Gupta, S.R. (2014). Ecology, Environment and Resource Conservation. S. Chand and Company Pvt. Ltd., New Delhi.
- Mathez, E. A. and Smerdon, J. (2009). Climate Change- The Science of Global Warming and Our Energy Future, Columbia University Press.

**BOT/4/ME/04: Medicinal Plants of Uttarakhand**  
(Credits: 4, Max Marks 100; 75 External Exam+ 25 internal assessment)

**Course outcomes:** After the completion of the course the students will be able to:

1. Understand the diversity and distribution of medicinal plants in Uttarakhand
2. Study the techniques/methods for the sustainable utilization of the medicinal plants.
3. Understand the economic importance of medicinal plants.

| Unit | Topic   | Total No. of lecturers/ hrs (48) |
|------|---|----------------------------------|
| 1    | Retrospect and prospects of medicinal plants  | 12                               |
| 2    | Brief history, properties, action and uses of some important medicinal plants; Diversity, distribution and indigenous uses of threatened medicinal plants | 12                               |
| 3    | Policies for conservation, management and marketing of medicinal plants   | 12                               |
| 4    | Economics and sustainable exploitation of resources   | 12                               |

**Suggested readings**

- Kala, C. P. (2010). Medicinal Plants of Uttarakhand: Diversity, Livelihood and Conservation, Biotech Books.
- Sah, R. (2004). Nature's Medicinal plants of Uttarakhand: Tree, shrubs and Climbers. Vol. I. Gyandodaya Prakashan, Nainital.
- Sah, R. (2004). Nature's Medicinal plants of Uttarakhand: Herbs, Grasses and Ferns. Vol. II. Gyandodaya Prakashan, Nainital.
- Arber, A. (1999). Herbal plants and Drugs. Mangal Deep Publications.
- Chopra, R.N., Nayar S.L. and Chopra, I.C. (1956). Glossary of Indian Medicinal Plants, C.S.I.R., New Delhi.

**IX Semester**

**BOT/III/CC/11: Paper IX: Plant Ecology****(Credits: 4, Max Marks 100; 75 External Exam+ 25 internal assessment)****Course outcomes:** After the completion of the course the students will be able to:

1. Understand the scope and concepts of ecology and discuss the biosphere, biomes and biogeography.
2. Analyze the process of ecological succession.
3. Evaluate the importance of the major world ecosystems.
4. To distinguish between species, populations, communities, ecosystem and biomes.

| <b>Unit</b> | <b>Topic</b>   | <b>Total No. of lecturers/ hrs (48)</b> |
|-------------|--|---|
| <b>1</b>    | 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.<br>Vegetation organization: Concepts of community and continuum; Community structure and attributes; Edges and ecotones; Keystone species and control of community structure.<br>Species interactions: Types of interactions, interspecific competition; Ammensalism; herbivory; parasitism; Commensalism, carnivory, pollination, symbiosis (obligate and facultative symbiosis).  | <b>12</b>                               |
| <b>2</b>    | Population Ecology: Characteristics of population; population growth curves; population regulation life history strategies (r and k selection); population genetics and natural selection.<br>Habitat and niche: Concept of habitat and niche; niche width and overlap, fundamental and realized niche.  | <b>12</b>                               |
| <b>3</b>    | Ecological succession: Causes, mechanism and types, changes involved in succession; Transient and cyclic changes; Examples of succession; Methods of standing succession; concept of climax.<br>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, Ecosystem modeling, restoration ecology, ecological engineering. | <b>12</b>                               |

|          |   |           |
|----------|---|-----------|
| <b>4</b> | <p>Applied Ecology: Biodiversity concept; Levels of Biodiversity: genetic, species, community and ecosystem diversity; Uses of biodiversity; Biodiversity, Ecosystem services and functions.</p> <p>Distribution of biodiversity; Gradients of biodiversity; Hotspots; Threats to biodiversity.</p> <p>Extinction of species: Biodiversity assessment and inventory; Conservation of biodiversity; Indices; biodiversity and its conservation; International efforts for conserving biodiversity.</p> | <b>12</b> |
| <b>5</b> | <p>Environmental pollution: kinds; sources; quality parameters; effects on plants and ecosystems and remedies.</p> <p>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.</p>   |           |

### Suggested readings

- Kormondy, E.J.(2017). Concept of Ecology. Pearson India.
- Singh, J.S. Singh S.P. and Gupta, S.R. (2014). Ecology, Environment and Resource Conservation. S. Chand and Company Pvt. Ltd., New Delhi.
- Baskin and Baskin, (2001). Seeds: Ecology, Biogeography and Evolution of Dormancy and Germination Elsevier
- Smith, R.L. (1996). Ecology and Field Biology Harper Collins, New York
- 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

### **BOT/III/CC/12: Paper X: PLANT RESOURCE UTILIZATION AND CONSERVATION**

**(Credits: 4, Max Marks 100; 75 External Exam+ 25 internal assessment)**

**Course outcomes:** After the completion of the course the students will be able to:

1. Describe economically important plants with binomial names, family and uses.
2. Understand the various uses of plants; biodiversity status, loss and management strategies
3. Understand the biogeography and initiatives for biodiversity conservation.

| Unit | Topic | Total No. of lecturers/ hrs<br>(48) |
|------|-------|-------------------------------------|
|------|-------|-------------------------------------|

|   |   |    |
|---|---|----|
| 1 | Sustainable development: Basic concepts.<br>World centres of primary diversity of domesticated plants: The Indo-Burmese centre plant introduction and secondary centres.<br>An introduction to (i) Food, forage and fodder crops. (ii) Fibre crops.<br>(iii) Medicinal and Aromatic Plants and (iv) Vegetable oil-yielding crops and their uses.  | 12 |
| 2 | 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.<br>Lesser known plants of Uttarakhand and their economic importance;<br>Wild edible plants of Uttarakhand<br>Green revolution: Benefits and adverse consequences.<br>Plants used as avenue trees for shade, pollution control and aesthetics.<br>Principles of conservation: extinction, status of plants based on International Union for Conservation of Nature (IUCN) |    |
| 3 | 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.   | 12 |
| 4 | Strategies for conservation- ex-situ conservation: Principles and practices; botanical gardens, field gene banks, seed banks, in vitro repositories, cryo-banks, 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), Department of Science and Technology (DST), and Department of Biotechnology (DBT) for conservation, non- formal conservation efforts.                     | 12 |

#### Suggested readings

- Kochhar S.L. (2016). Economic Botany. Cambridge University Press, London.
- Pullin A.S. (2002). Conservation Biology. Cambridge University, Press, London.
- Frankel O.H, Brown A.D.H. and Burdon J.J. (1995). The Conservation by Plant Diversity Technical guidelines for the site movement of Germplasm (1989) by FAO IBPGR.
- Pandey, B.P. (1999). Economic Botany. S. Chand, New Delhi.
- Watson, R.T., Heywood, V.H., Baste, T., Dias, B., Gámez, R., Janetos, T., Reid, W. Ruark, G. (1995). Global biodiversity assessment: summary for policy-makers. Cambridge(England).
- Paroda R.S. and Arora R.K. (1991). Plant genetic resources Conservation and Management. International Board for Plant Genetic Resources, (IBPGR), Rome, (Italy)

#### **BOT/III/CC/13: Paper XI: Biotechnology**

**(Credits: 4, Max Marks 100; 75 External Exam+ 25 internal assessment)**

**Course outcomes:** After the completion of the course the students will be able to

1. Understand the process and techniques of bio-technology and plant tissue culture.



2. Analyze the tools and techniques used in genetic engineering
3. Evaluate the methods and applications of recombinant DNA technology.
4. Understand the blotting techniques, DNA sequencing, and genetic engineering of plants.

| Unit | Topic   | Total No. of lecturers/ hrs (48) |
|------|---|----------------------------------|
| 1    | Biotechnology: Principle and scope, bio-safety guidelines.<br>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.   | 12                               |
| 2    | Callus culture, organ culture, cell suspension culture, cryopreservation, protoplast culture, organogenesis, somatic embryogenesis, artificial seed, somatic hybridization, hybrids and cybrids, and somaclonal variation.  | 12                               |
| 3    | Recombinant DNA technology: Tools of genetic engineering, enzymes, cloning vectors, plasmids, cosmids, lamda phage, shuttle vectors, BACs, and YACs.<br>Cloning strategies, Screening and selection of transformants.   | 12                               |
| 4    | Gene libraries (a general account): Genomic DNA libraries, cDNA libraries.<br>Hybridization- colony hybridization, Southern hybridization, Northern hybridization, Western hybridization, DNA sequencing techniques: Maxam and Gilbert sequencing, Sanger sequencing<br>Genetic Engineering of plants: Aims, tools, strategies for development of transgenic plants with suitable examples. | 12                               |

#### Suggested readings

- Brown, T.A. (2018). Genomes 4. John Wiley and Sons (Asia) Pvt. Ltd. Singapore.
- Chrispeels, M.J. and Gepts, P. (2017). Plants, Genes and Agriculture. Oxford University Press.
- Gustafson, J.P. (2000). Genomes. Kluwer Academic Plenum Publishers, New York, USA.
- Jolles, O. and Jornvall, H. (2000). Proteomics in Function Genomics. Birkhauser. Verlag, Basel, Switzerland.
- Shantharam, S. and Montgomery, J.F. (1999). Biotechnology, Biosafety and Biodiversity. Oxford and IBH Publishing Co. Pvt. Ltd. New Delhi.
- Collins, H.A. and Edwards, S. (1998). Plant Cell Culture. Bioscientific Publishers, Oxford, UK.
- Raghavan, V. (1997). Molecular Biology in Flowering Plants. Cambridge University Press, New York, USA.
- Callow, J.A., Ford-Lloyd, B.V. and Newbury, H.J. (1997). Biotechnology and Plant Genetic Resources: Conservation and Use. Cab International, Oxon, UK.
- Henry, R.J. (1997). Practical Application of Plant Molecular Biology. Chapman & Hall, London, UK.
- Jain, S.M., Sopory, S.K. and Veilleux, R.E. (1996). In Vitro Haploid Production in Higher Plants, Vols, 1-5., Fundamental Aspects and Methods. Kluwer Academic Publishers, Dordrecht, The Netherlands.
- Glazer, A.N. and Nikaido, H. (1995). Microbial Biotechnology, W.H. Freeman and Company, New York, USA.

- Primose, S.B. (1995). Principles of Genome Analysis. Blackwell Science Ltd, Oxford, UK.
- Vasil, I.K. and Thorpe, T.A. (1994). Plant Cell and Tissue Culture. Kluwer Academic Publishers, The Netherlands.
- Bhojwani, S.S. (1990). Plant Tissue Culture: Applications and Limitations. Elsevier Science Publishers, New York, USA.
- Kartha, K.K. (1985). Cryopreservation of Plant Cells and Organs. CRC Press, Boca Raton. Florida, USA.
- 

**BOT/III/CC/14: Paper XII: Plant Physiology**

**(Credits: 4, Max Marks 100; 75 External Exam+ 25 internal assessment)**

**Course outcomes:** After the completion of the course the students will be able to:

1. Understand the mechanism of transport and translocation of water and analyze the mechanisms of acclimation and adaptation of plants to stress conditions.
2. Understand the process of transpiration, photosynthesis and respiration and analyze these techniques in various groups of plants.
3. Attain awareness on the nitrogen cycle and the role of microbes and plants in the nitrogen cycle.
4. Understand the role of plant growth regulators and photoreceptors in plant growth and development.

| Unit     | Topic   | Total No. of lecturers/ hrs (48) |
|----------|---|----------------------------------|
| <b>1</b> | 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.<br>Signal transduction and sensory photobiology: Receptors, phospholipids signaling, phytochromes and cryptochromes.  | <b>12</b>                        |
| <b>2</b> | 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<br>Respiration: Glycolysis. TCA cycle, electron transport chain and ATP synthesis, pentose- phosphate pathway, glyoxylate cycle.<br>Nitrogen fixation and metabolism: Biological nitrogen fixation, mechanism of nitrate uptake and reduction, ammonia assimilation. | <b>12</b>                        |

|          |  |           |
|----------|--|-----------|
| <b>3</b> | 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.<br>Photoperiodism and vernalization and their significance;<br>Floral induction and development | <b>12</b> |
| <b>4</b> | Stress physiology: Plant responses to biotic and abiotic stresses, mechanism of biotic and abiotic stress tolerance, water deficit and drought resistance, salinity stress, freezing and heat stress, oxidative stress.  | <b>12</b> |

#### Suggested readings

- Taiz, L; Zeiger, E; Moller, I. M. and Murphy A. (2014). Plant Physiology and Development. Publisher: Sinauer Associates Inc. print of Oxford University Press. 6<sup>th</sup> Edition.
- Huner, N.P.A, and Hopkins, W. G. (2008). Introduction to Plant Physiology. Wiley 4<sup>th</sup> Edition.
- Devi, P. (2000). Principles and methods of Plant Molecular Biology, Biochemistry and Genetics. Agrobios.
- Buchanan, B.B, Gruissem W. and Jones, R.L. (1996). Biochemistry and Molecular Biology of plants by Enzymes: A practical introduction to structure, mechanism and data analysis. R. A. Copeland.
- Scott, R.P.W. (1995). Techniques and Practice of Chromatography. Taylor and Francis, Routledge.

#### Practical/ Lab Course (BOT/III/CC/15: Based on the CC/09 to CC/12 papers)

#### Semester X

#### BOT/IV/CC/16: Core Course Paper XIII: Biochemistry (Credits: 4, Max Marks 100; 75 External Exam+ 25 internal assessment)

**Course outcomes:** After the completion of the course the students will be able to

1. Understand the structure, classification and functions of biochemical compounds
2. Understand the structure, functions and biochemical pathway of secondary metabolites.
3. Understand the catalytic mechanism of enzymes, its inhibitors and regulation.

| Unit     | Topic   | Total No. of lecturers/ hrs (48) |
|----------|---|----------------------------------|
| <b>1</b> | Carbohydrates: structure and function of Monosaccharides oligosaccharides, polysaccharides, Glycolysis, Feeder pathway<br>Lipids: Fat metabolism (Simple lipids, compound lipids, derived lipids), fat metabolism, $\beta$ - oxidation. | <b>12</b>                        |
| <b>2</b> | Proteins: Amino acids, Structure of primary, secondary, tertiary, quaternary proteins, Ramachandran plot, protein sequencing.   | <b>12</b>                        |

|          |   |           |
|----------|---|-----------|
| <b>3</b> | Secondary metabolites: Alkaloids, flavanoid, terpenoid and their biosynthetic pathway.  | <b>12</b> |
| <b>4</b> | Enzymology: General aspects, allosteric mechanism, regulatory and active sites, isozymes, kinetics of enzymatic analysis, Michaelis - Menten equation and its significance, enzyme inhibition (competitive, uncompetitive and non - competitive). | <b>12</b> |

### Suggested readings

- Nelson, D. L. and Cox, M. M. (2021). Lehninger. Principles of Biotechnology. Macmillan, 8<sup>th</sup> Edition.
- Srivastava, H.S. (2003). Elements of Biochemistry. Rastogi Publications, Meerut.
- Cooper, T.G. (1977). Tools in Biochemistry. Wiley New York.
- Bosch, C. (1972). Mechanism of Protein Synthesis and its Regulation. Elsevier Pub. Comp. N. York.
- Ribonsen, T. (1968). The biochemistry of Alkaloides Springer Verlag, Berlin
- Meister, A. (1965). Biochemistry of the Amino acids. 2 vols. Academic Press, New York.

### BOT/IV/CC/17: Core Course Paper XIV: Cell Biology

**(Credits: 4, Max Marks 100; 75 External Exam+ 25 internal assessment)**

**Course outcomes:** After the completion of the course the students will be able to

1. Understand the various aspects of cell biology.
2. Study the structure and function of various cell organelles.
3. Understand the cell cycle, its regulation and apoptosis.
4. Study various techniques used in cell biology.

| Unit     | Topic  | Total No. of lecturers/hrs (48) |
|----------|--|---------------------------------|
| <b>1</b> | <b>Cell Wall:</b> Structure and Function<br><br><b>Plasma Membrane:</b> Structure, models and functions, Plasmodesmata and their role in movement of molecules and macromolecules  | <b>12</b>                       |
| <b>2</b> | <b>Chloroplast:</b> Structure and genome organization and transcription<br><br><b>Mitochondria:</b> Structure, genome organization, biogenesis, RNA editing<br><br><b>Plant vacuoles:</b> Tonoplast membrane, ATPase, storage organelles<br><br><b>Nucleus:</b> Structure, DNA structure, A, B and Z forms, nuclear pores, nucleosome organization<br><br><b>Ribosomes:</b> Structure, protein synthesis, mechanism of translocation, Initiation and termination | <b>16</b>                       |

|   |  |    |
|---|--|----|
| 3 | <p><b>Cell shape and mortality:</b> The cytoskeleton , organization and role of microtubules and microfilaments</p> <p><b>Cell cycle and Apoptosis:</b> Role of cyclins and cyclin-dependent kinase, cytokinesis and cell plate formation.</p>                             | 10 |
| 4 | <p><b>Other cellular organelles:</b> structure and functions of microbodies, Golgi apparatus, lysosomes, endoplasmic reticulum</p> <p><b>Techniques in Cell Biology:</b> Immunotechnology, FISH, GISH, Confocal microscopy</p> <p><b>Immunology :</b> Basic techniques</p> | 10 |

#### Suggested readings

- Hopkin, A. Morgan, J. Roberts, R and Walters (2019). Essentials of Cell Biology (5<sup>th</sup> Edition). International Student Edition.
- Rastogi, V. B. Cell Biology. Medtech Science Press: A Division of Scientific International.
- Verma, P.S. and Agrawal, V. K.. Cell Biology. (2016) S. Chand and Company, New Delhi.

#### **BOT/IV/EC/18(i): Elective Course/Special Paper XV (i): Forest Ecology**

**(Credits: 4, Max Marks: 100; 75 External Exam+ 25 internal assessment)**

**Course outcomes:** After the completion of the course the students will be able to:

1. Understand the structure and function of forest ecosystem.
2. Understand methods for studying vegetation, community pattern and processes, ecosystem function, biodiversity, carbon stock and carbon sequestration.
3. Help the students to understand the linkage between men and forests.

| Unit | Topic | Total No. of lecturers/hrs (48) |
|------|-------|---------------------------------|
|------|-------|---------------------------------|

|   |  |    |
|---|--|----|
| 1 | <p>General Aspects of Forests: Forest ecology and forest ecosystem, Importance of forests in environmental conservation, Biodiversity and climate change.</p> <p>Primary Productivity and Detritus Pool: Solar radiation and energy units; Concept of primary productivity.</p> <p>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 ;</p> <p>Human Use of Productivity; Environmental factors and productivity.</p>  | 12 |
| 2 | <p>Litter fall in Forest Ecosystems; determining litter fall, factors affecting it; Forest litter: type of litter; Coarse Woody debris; forest floor litter mass.</p> <p>Detritus Pathway of Energy Flow and Decomposition Processes: Decomposer organisms and their trophic interactions; decomposition processes; Measurements of Litter Decomposition; Decomposition rate.</p>  | 12 |
| 3 | <p>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), nutrient re-translocation.</p> <p>Stream water losses, losses to the atmosphere; Nutrient losses due to fire, nutrient losses in forest harvest;</p> <p>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 re-absorption; 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.</p> <p>Forest Hydrology: Impact of forest on precipitation apportionment, Water discharge from watersheds, Role of water in nutrients cycling.</p> | 12 |
| 4 | <p>Succession: An idea of forest succession</p> <p>Major forest types of India: Forest classification of India; Forest of Himalaya with particular reference to Sal, Pine and Oak forests.</p> <p>Global climate changes and forests.</p> <p>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.</p>  | 12 |

### Suggested reading

- Singh, J.S. and Singh, S.P. (2014). Forest of Himalaya: structure, Function and Impact of Man. Gyanodaya Prakashan, Nainital, India.
- Singh, J.S. Singh S.P. and Gupta, S.R. (2014). Ecology, Environment and Resource Conservation. S. Chand and Compony Pvt. Ltd., New Delhi.
- Bir, S.S. and Chatha, G.S. (1988). Forest Vegetation Characteristics of Indian Hills. Today and Tomorrow's Printers & Publ., New Delhi.
- Waring, R.H. and Schlesinger, W.H. (1985). Forest Ecosystems: Concepts and Management. Academic Press, New York.
- Misra, R. (1968). Ecology Work Book. Oxford & IBH Publishing Co. New Delhi.
- Puri, G.S., Meher-Homji V.M., Gupta R.K. and Puri R.K. (1960). Forest Ecology. Oxford and IBH Pub.Co. Pvt. New Delhi.

### **BOT/IV/EC/18 (ii): Elective course/special paper (ii): Plant Pathology**

**(Credits: 4, Max Marks 100; 75 External Exam+ 25 internal assessment)**

**Course outcomes:** After the completion of the course the students will be able to

1. General characteristics of plant pathogenic organisms including fungi, bacteria, viruses and mycoplasma.
2. Study of interaction between plant and pathogen in relation to the environment and mechanism of disease development by pathogens.
3. Understand the genetics of host parasite interaction.
4. Understand the various enzymes and toxins involved in disease development.
5. Study of various important plant diseases, disease cycle and control measures.

| Unit | Topic  | Total No. of lecturers/ hrs (48) |
|------|--|----------------------------------|
| 1    | A brief history of plant pathology in India and losses caused by pathogens and pests; Types of pathogens, symptoms of different plant diseases.<br><b>Inoculum:</b> Inoculum types, theory of inoculums, survival and longevity of inoculums, inoculums production, potential and density.<br><b>Plant microbe interaction:</b> molecular basis of host recognition, pathogenesis: pre-penetration, penetration and post penetration events, factors affecting disease development (host factors, environmental factors, virulence susceptibility).<br><b>Dissemination of pathogens:</b> Means of dissemination (active and passive dissemination). | 12                               |

|   |   |    |
|---|---|----|
| 2 | <p><b>Genetics and host parasite interaction:</b> Concept of compatibility and specificity, gene for gene relationship, genetics of resistance, source of resistance, inheritance of resistance in the host.</p> <p><b>Enzymes and toxins:</b> Enzymes involved in disease development, toxins and their role in plant health.</p> <p><b>Physiology of diseased hosts:</b> Change in physiology processes, e.g., respiration, photosynthesis and disturbance in other metabolic pathways.</p>   | 12 |
| 3 | <p><b>Disease resistance:</b> (i) Protection (structural, chemical, absence of nutrients and common antigens).</p> <p><b>Defense</b> (histological defense, chemical- polyphenols, prohibitins, inhabitins, phytoalexins, lectins).</p> <p><b>Genetic resistance:</b> resistant genes, biotechnological approaches for transfer of R- genes into susceptible plant.</p> <p><b>Seed pathology:</b> 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.</p> <p><b>Disease control:</b> Cultural practices, chemical methods (insecticides, systemic and non-systemic chemical), biological control: Introduction, biological control of insects and pests, use of resistance varieties and plant quarantine.</p> | 12 |
| 4 | <p>Brief account, structure, importance, disease cycle and control of the following diseases:</p> <p>(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.</p> <p>General characteristics, importance, disease cycle and control of the following: (i) Bacterial disease, (ii) Viral disease, (iii) Mycoplasma disease.</p>  | 12 |

### Suggested readings

- Mehrotra, R. S. (2013). Plant Pathology. Tata Mc Grow Hill Publishing Co Ltd. New Delhi.
- Agrios, G.N. (2011). Plant Pathology. Elsevier.
- Bouarab, N. K., N. Bissow and F. Daayf. (2009). Molecular Plant Microbe Interactions.
- Mehrotra, R. S. and Agrawal, A. (2003). Plant Pathology. Tata Mc Grow Hill Publishing Co Ltd. New Delhi.
- Lucas, J.A. (1988). Plant Pathology and Plant Pathogens. Third edition. Blackwell.
- Singh, R. S. (1988). "Plant diseases". Oxford and IBH Publishing Co. Pvt. Ltd. New Delhi.
- Butler, E. J. (1918). Fungi and Diseases in plants. Thacker and Spink and Cooperation. Calcutta.

### **BOT/IV/EC/18 (iii): Elective course/Special paper (iii): Taxonomy of Angiosperms (Credits: 4, Max Marks 100; 75 External Exam+ 25 internal assessment)**

**Course outcomes:** After the completion of the course the students will be able to

1. Understand the naming of the plant through plant nomenclature.
2. Learn the phylogeny and classification of angiosperms of system their use and utility.
3. Identify the various angiosperms families with specific key characters.



4. Learn various advanced tools to study plant taxonomy.

| Unit | Topic   | Total No. of lecturers/ hrs(48) |
|------|---|---------------------------------|
| 1    | History of different systems of classification (introduction only). Important systems- Bentham and Hooker, Hutchinson, A. Takhtajan, A. Cronquist, Robert Thorne, Angiosperm Phylogeny Group (APG IV) classification.<br>A brief account of major contributions made by the following taxonomists: C. Linnaeus, J.D. Hooker, Willium Roxburgh and Duthie. | 12                              |
| 2    | Taxonomic evidences- wood anatomy, embryology, palynology, cytotaxonomy, biosystematics, chemotaxonomy and numerical taxonomy.<br>Relevance of taxonomy to conservation, Cladistics.  | 12                              |
| 3    | Some important families: Magnoliaceae, Myrtaceae, Scrophulariaceae, Verbenaceae, Loranthaceae, Cannabaceae, Moraceae, Fagaceae, Orchidaceae, Zingiberaceae, Cyperaceae, Poaceae.  | 12                              |
| 4    | Local plant diversity and general account of Kumaun flora; Wild and cultivated fruits of Kumaun.  | 12                              |

#### Suggested readings

- Angiosperm Phylogeny Group (APG-2016). An update of the Angiosperm Phylogeny Group Classification for the orders and families of flowering plants: APG IV. Botanical Journal of the Linnaean Society 181: 1-20.
- Saxena, N.B. and Saxena, S. (2012). Plant Taxonomy. Pragati Prakashan.
- Sambamurty A.V.S.S. (2010). Taxonomy of Angiosperms. I.K. International Pvt. Ltd
- Singh, G. (2010). Plant Systematics. CBS PUB & DIST PVT Limited INDIA.
- Sharma, O.P. (2009). Plant Taxonomy. Tata McGraw-Hill Publishing Company Limited, New Delhi.
- Gaur R.D. (1999). Flora of District Garhwal, N.W. Himalaya Transmedia, Srinagar Garhwal.
- Bhattacharya B. and B.M. Joshi. (1998). Flowering plants. Taxonomy and phylogeny Norsa publishing house New Delhi.
- Heywood V.H. and D.M. Moore. (1984). Current concept in plant taxonomy. Systematic special volume 25. London.
- Davis P.H. and Heywood V.H. (1973). Principles of angiosperms taxonomy. Robert E. Kreign Pub. Co. New York.
- Heywood V.H. (1970). Plant taxonomy London.
- Bensen L. (1957). Plant Classification reprint. Oxford & IBH N. Delhi.
- Lawrence G.H.M. (1951). Taxonomy of vascular plants. Mac Millan N.York.

#### **BOT/IV/EC/18 (iv): Elective Course/Special Paper (iv): Ethnobotany, Traditional Knowledge And Intellectual Property Rights**

**(Credits: 4, Max Marks 100; 75 External Exam+ 25 internal assessment)**

**Course outcomes:** After the completion of the course the students will be able to

1. Understand the concept, scope and importance of ethnobotany.

2. Study the ethnobotany of major tribal communities of Uttarakhand.
3. Understand the concepts and implications of Intellectual property rights.

| Unit | Topic   | Total No. of lecturers/ hrs (48) |
|------|---|----------------------------------|
| 1    | Ethnobotany: Its Concept, Scope and Relevance. Interdisciplinary approaches in Ethnobotany. Ethnobotany in India: Retrospect and prospects. Methods of research in Ethnobotany.   | 12                               |
| 2    | Indigenous systems of medicines in India. Traditional Agriculture Practices in Ancient India. Some aspects of Biodiversity and Indian Traditions. Traditional knowledge of Uttarakhand: With special reference to food and medicine. Ethnobotany of major tribal communities (Raji, Bhotia, Tharu and Boxa) of Uttarakhand. Changing values in traditional societies and ecological implications. | 12                               |
| 3    | Role of ethnobotany in primary health care programs; Ethnobotany on development and conservation on bioresources with reference to Himalayan region. Plant exploration; Crop and Germplasm collection of land races: Methods and strategies.  | 12                               |
| 4    | Basic concepts of Intellectual Property Rights (IPRs). The implications of the Intellectual Property Rights on the Convention on Biological Diversity (CBD). Intellectual Property Rights with particular reference to Traditional knowledge and Biowealth.   | 12                               |

#### Suggested readings

- Jain, S.K. (1989). Method of Approaches in Ethnobotany. Lucknow.
- Jain, S.K. (2010). A Manual of Ethnobotany. Scientific Publishers.
- Pande, P.C., Pokharia D.S. and Bhatt J.C. (1999 Ed.). Ethnobotany of Kumaun Himalaya. Jodhpur.
- Wariko, K. (1995). Society and culture in the Himalaya. New Delhi.
- Yamin, F. (1995). The Biodiversity Conservation and Intellectual Property Rights. Switzerland.
- Krattigar, F. Anatole (1994). Widening Perspectives on Biodiversity. Dehradun.
- Martin, G.J. (1994). Ethnobotany: A Method Manual. London.
- Paroda, R.S. and Arora, R.K. (1991). Plant Genetics Resoueces Conservation and Management concepts and approaches. New Delhi.
- Jain, S.K. and Mudgal, V. (1999). A handbook of Ethnobotany. Dehradun.

#### **BOT/IV/EC/18 (v): Elective Course/Special Paper (v): BRYOLOGY**

**(Credits: 4, Max Marks 100; 75 External Exam+ 25 internal assessment)**

**Course outcomes:** After the completion of the course the students will be able to:

1. Understand the general idea about morphology, cytology and reproduction in Bryophyta.
2. Study evolutionary trends and modern systems of classification of bryophytes.

3. Understand the ecological and economic Importance of bryophytes
4. Understand the ecology, physiology and chemistry of bryophytes.
5. Study the general characters and life cycle of some important bryophytes.

| Unit     | Topic  | Total No. of lecturers/ hrs (48) |
|----------|--|----------------------------------|
|          | Distribution of bryophytes in India, the bryogeographical units: Vanishing bryophytes in Kumaun Himalaya, the red List monotypic, endemic liverwort taxa. Rare and endangered liverworts of Kumaun Himalaya.<br>Taxonomic methodology in the identification of some common western himalayan mosses, distinguishing features of the following genera: <ul style="list-style-type: none"> <li>➤ <i>Pogonatum</i></li> <li>➤ <i>Atricum</i></li> <li>➤ <i>Fissidens</i></li> <li>➤ <i>Dieranum</i></li> <li>➤ <i>Hyophila</i></li> <li>➤ <i>Hydrogonium</i></li> <li>➤ <i>Grimmia</i></li> <li>➤ <i>Rhacomitrium</i></li> <li>➤ <i>Bryum</i></li> <li>➤ <i>Rhodobryum</i></li> <li>➤ <i>Mnium</i></li> <li>➤ <i>Philonotis</i></li> <li>➤ <i>Macromitrium</i></li> <li>➤ <i>Leucodan</i></li> <li>➤ <i>Meteorium</i></li> <li>➤ <i>Neeckera</i></li> <li>➤ <i>Cryptoleptodon</i></li> <li>➤ <i>Thuidium</i></li> <li>➤ <i>Anomodon</i></li> <li>➤ <i>Herpetin</i></li> <li>➤ <i>Brachythecium</i></li> <li>➤ <i>Entodaon</i></li> <li>➤ <i>Hypnum</i></li> </ul> | <b>12</b>                        |
| <b>2</b> | Bryophyte ecology: Habitats, growth forms, the role of bryophytes in succession, bryophytes as bio- indicators and their response to air pollution.  | <b>12</b>                        |
| <b>3</b> | Physiology of bryophytes: General idea of conduction in bryophytes, ecto, exo and mesohydric groups, desiccation and hydration, desiccation tolerance.   | <b>12</b>                        |
| <b>4</b> | A general idea of culture techniques for bryophytes. Chemistry of bryophytes: A brief account of distribution of various organic compounds in bryophytes and their uses in medicines.  | <b>12</b>                        |

#### Suggested readings

- Chopra, R.N. and Kumar, P.K. (2019). Biology of Bryophytes. New Age International Pub. KUN

- Vashishta, P. C. Sinha, A. K. and Kumar A. (2010). Bryophyta. S. Chamd Delhi, India.
- Ganguly, S.C. (1969-1980). Mosses of Eastern India and Adjacent regions Vol. I. Vol. II and Vol III.

**BOT/IV/EC/18(vi): Elective Course/Special Paper (vi): Lichenology**  
(Credits: 4, Max Marks 100; 75 External Exam+ 25 internal assessment)

**Course outcomes:** After the completion of the course the students will be able to

1. Understand the general characters, structure, types, reproduction and various habitats of lichens.
2. Understand the physiology and biochemistry of plants.
3. Study the ecological and economic importance of lichens.
4. Study the major lichen families and their representative genera.

|          | <b>Topic</b>   | <b>Total No. of lecturers/ hrs (48)</b> |
|----------|--|---|
| <b>1</b> | History of Lichenology, Biogeographical distribution, habitat and growth form of lichens; Classification; Symbiosis in lichens-types of symbiotic association, Identification, morphological, anatomical and chemical methods (spot test, thin layer chromatography, microcrystallography and UV fluorescence analysis), biotechnological aspects of lichens.  | <b>12</b>                               |
| <b>2</b> | Reproduction- asexual and sexual means lichenized and non lichenized diaspores, isidia, soredia, conidia, parithecia and apothecia.<br>Chemistry- chemical composition of lichens primary and secondary metabolites, major pathway of secondary metabolite formation.<br>Physiology- nutrients, elemental accumulation and mineral cycling, nitrogen metabolism and lichen sensitivity to air pollution. | <b>12</b>                               |
| <b>3</b> | Role of lichens in environmental monitoring- pollution succession, lichenometry, pedogenesis and biodeterioration.<br>Importance of lichens- as food, medicine, dyes, perfumery etc An elementary idea of lichen tissue culture. Tools and techniques used in identification of some common Central Himalayan lichens.   | <b>12</b>                               |
| <b>4</b> | Families and their representative genera: Parmeliaceae, Lecanoraceae, Teloschistaceae, Ramalinaceae, Physciaceae, Collemataceae, Candelariaceae, Pertusariaceae, Peltigeraceae. Lichen flora of Kumaun Himalaya general account.   | <b>12</b>                               |

#### **Suggested readings**

- Arya, V., Kumar, B. and Arya, P. (2019). Lichen Wealth of Uttarakhand Himalaya. Lap Lambert Academic Publishing.
- Nash, T.H. (2008). Lichen biology, UK.
- Awasthi, D.D. (2007). A compendium of the macrolichens of India, Nepal and Srilanka. Dehradun Bishen Singh Mahendra pal Singh: Dehradun India.
- Divakar, P.K and Upreti, D.K. (2005). Parmelioid lichens in India (A revisionary study), Bishen Singh Mahendrapal Singh: Dehradun India.
- Botany PG (NEP) KUN

- Orange, A., James, P.W and White, FJ. (2001). Crochemical methods of identification of lichen, British lichen society, London.
- Awasthi, D.D. (2000). Hand book of lichens, Bishen Singh Mahendra pal Singh: Dehradun India.
- Smith, A.L. (1921). Lichen Cambridge University Press, London

*N. K. Singh*  
19-06-2023

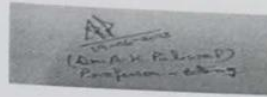
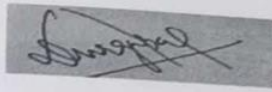
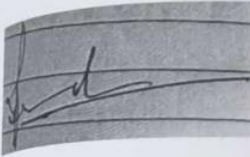
*C. S. Singh*  
19/06/2023

*P. Singh*  
19.6.2023

*S. Singh*  
19/06/23

*Abhishek*  
19-06-2023

*K. Bengali*  
19.6.2023



*S. Singh*  
19/6/2023

*R. Singh*

Professor & Head  
Department of Botany  
D.S.B. Campus  
Kumaun University, Nainital - 263001  
Uttarakhand (India)

*S. Singh*  
19/6/2023  
Dean  
Faculty of Science  
Kumaun University  
Nainital