



# Shri Guru Ram Rai University

(Estd. By Govt. of Uttarakhand, vide Shri Guru Ram Rai University Act No. 03 of 2017 Act No. 03 of July 2017)

Patel Nagar, Dehradun-248001, Uttarakhand.

**"Minutes of Meeting"**  
Department of Botany,  
(School of Basic and Applied Sciences)

**FOURTH MEETING OF THE BOARD OF STUDIES IN BOTANY**  
**(UG FOUR YEAR PROGRAM AS PER NEP 2020, PG AND PRE PhD**  
**COURSE WORK)**  
(3<sup>rd</sup> July, 2023)

The fourth meeting of the Board of Studies in Botany was held today i.e. on 3<sup>rd</sup> July, 2023 in pursuance to University directive commencing from 11:00 AM onwards at Department of Botany, School of Basic and Applied Sciences, Shri Guru Ram Rai University, Dehradun.

The following members were present:

1. Prof. (Dr.) Arun Kumar, Dean, School of Basic & Applied Sciences, Shri Guru Ram Rai University, Dehradun (Chairperson)
2. Prof. (Dr.) A R. Nautiyal (Retd.), HAPPRC, HNB Garhwal Central University (External Expert)
3. Prof. (Dr.) Maneesha Singh, Convenor, Department of Botany (Convenor)
4. Prof. (Dr) Kumud Saklani, Dean Academics, SGRRU (Member)
5. Dr. Saurabh Guleri, Associate Professor, Department of Botany (Member)
6. Prof. Dr Rajesh Rayal HOD, Department of Zoology (Member)
7. Dr. Sheetal Tyagi, HOD, Department of Chemistry (Member)
8. Dr. Shahana Jabi, Assistant Professor, Department of Botany (Member)
9. Dr. Kanchan Bhardwaj, Assistant Professor, Department of Botany (Member)

**PROCEEDINGS AND RESOLUTIONS:**

The members of the BOS discussed the agenda item wise and resolutions were made accordingly

**Agenda No. 1: To confirm the minutes of meeting of the third Board of Studies in Botany held on 3<sup>rd</sup> January, 2023.**

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**Resolution:** The board confirmed the minutes of the last Board of Studies meeting held on 3<sup>rd</sup> January, 2023 with the modifications as per Curriculum and Credit Framework for Undergraduate and NHEQF (National Higher Education Qualifications Framework).

**Agenda No. 2: Introduction and implementation of revised UG program of NEP-2020 from the Academic Session 2023-24 & Inclusion and finalization of Program outcomes (POs), Program-specific outcomes (PSOs), Course outcomes (COs) and Syllabus of B.Sc. Botany as per NEP 2020 and CBCS.**

**Resolution:** It was recommended and approved by the members of the board that from the academic session 2023-24 revised UG program shall be introduced in Department of Botany (As per Annexure-1) and implementing NEP in the UG course and Program outcomes (POs), Program-specific outcomes (PSOs), and Course outcomes (COs) and syllabus for B.Sc. Botany shall be included in the curriculum with the recommendation to revise the course in future as per the requirement.

**Agenda 3: Allotment and description of course code and credits to different courses in the UG and PG program for all semesters.**

**Resolution:**

- The course codes in the UG programme were allotted as per UGC guidelines and university norms and all the members resolved to approve the same. Credit system in the UG were approved as per UGC norms/ NEP guidelines (as per annexure 1).
- The theory lectures were of 3 credits each, all laboratory courses were of 4 credits and dissertation of 10 credits for PG course programme.

**Agenda no 4: To consider distribution of courses of all semesters in M.Sc. botany as per CBCS for the academic year 2023-24 and consider revision of course contents with addition, deletion or modification in syllabi, if required.**

**Resolution:** The distribution of courses for all semesters in the PG program as per CBCS was discussed in details with the honourable members and it was resolved to approve and implement the same for the academic session 2023-24 with the recommendation to revise minor course contents as follows:

In the following courses in II and IV Semesters

S.No.	Program	Course category	Course code	Course name
1.	M.Sc. Botany	Core	MBOC203	Cytogenetics and Molecular Biology
2.	M.Sc. Botany	Core	MBOL 206	Laboratory Course -- I Based on C203 & C204
3.	M.Sc. Botany	Core	MBOL 403	Laboratory Course -- I Based on C401&C402

**Agenda No. 5: To revise the course outcome for pre PhD program in Botany.**

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**Resolution:** The board confirmed and approved the six course outcomes of core courses -Research Methodology (PRMC 101) and Research & Publications Ethics (RPEC 102) in botany as per SGRRU norms and UGC guidelines.

**Agenda No. 6: Medium of instruction, question paper pattern, medium of examination, and duration of examination, allotment of marks in internal and external exams.**

**Resolution:**

- The members were of the view and recommended that the medium of instruction shall be English medium/Hindi medium for UG Course program as per SGRR University norms.
- It was resolved by all the members that the duration of the End term examination shall be as per the guidelines issued by the Board of Examination SGRR University from time to time including the duration of Lab Course examinations.
- Each paper shall be of 100 marks. The allotment of marks in Pre-PhD course work shall be according to PhD ordinance of SGRR University. The distribution of mid-term and end term examination marks will be as per guidelines issued by the Board of Examination SGRR University from time to time.

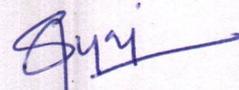
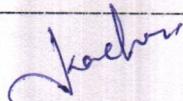
**Agenda No.7: Any other matter with due permission of Chairperson**

**Resolution:**

- Revision of list of books and Addition of e-books and e- resources
- Addition of Research Methodology BOTDE 705 as an elective course paper in VII semester as per SGRRU ordinance.

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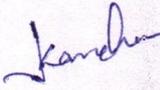
ATTENDANCE SHEET OF FOURTH MEETING OF THE BOARD OF STUDIES IN  
BOTANY

SN	Name of Members	Signature
1.	Prof. (Dr.) Arun Kumar, Dean, School of Basic & Applied Sciences, Shri Guru Ram Rai University, Dehradun (Chairperson)	
2.	Prof. (Dr.) A R. Nautiyal (Retd.), HAPPRC, HNB Garhwal University (External Expert)	
3.	Prof. (Dr.) Maneesha Singh, Convenor, Department of Botany (Convenor)	
4.	Prof. (Dr) Kumud Saklani, Dean Academics, SGRRU (Member)	
5.	Dr. Saurabh Guleri, Associate Professor, Department of Botany (Member)	
6.	Prof. Dr Rajesh Rayal, HOD, Department of Zoology (Member)	
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# SHRI GURU RAM RAI UNIVERSITY

[Estd. by Govt. of Uttarakhand, vide Shri Guru Ram Rai University Act no. 03 of 2017 & recognized by UGC u/s (2f) of UGC Act 1956]



## DEPARTMENT OF BOTANY SCHOOL OF BASIC & APPLIED SCIENCES SHRI GURU RAM RAI UNIVERSITY

Bachelor of Science  
OR  
Bachelor of Science (Hons.) with Research

Based on NEP 2020

[Exit Options after completion of 01 Year, 02 Years, 03 Years, and 04 Years]  
Effective from Academic Session 2023-2024

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Patel Nagar, Dehradun, Uttarakhand

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Basic Structure of UG Multidisciplinary Programme (with Three Core Disciplines) –  
**B.Sc. with Botany, Zoology, and Chemistry as core disciplines**

**Type of Course**

Discipline Specific Core (DSC)

Discipline Specific Elective (DSE)

General Elective (GE)

Ability Enhancement Courses (AEC)

Skill Enhancement Course (SEC)

Internship/Apprenticeship / Project/ Community Outreach (IAPC)

Value Addition course (VAC)

Sem	Core - Discipline Specific Core (DSC)	Elective- Discipline Specific Elective (DSE)	Elective- Generic Elective (GE)	Ability Enhancem ent Course (AEC)	Skill Enhancement Course (SEC)	(Internship /Apprentic eship / Project/ Community Outreach) (IAPC)	Value Addition Course (VAC)	Total credits
	Course/credit distribution (Credits 4)  Theory or Theory + Practicum (3T+1L)	Course/ credit distribution (Credits 4) Theory or Theory + Practicum/ Lab (3T+1L or 2T+2L)	Course/ credit distribution (Credits 4) Theory or Theory + Practicum/ Lab (Credits 4T or 3T+1L or 2T+2L)	Course/ credit distribution (Credits 2)	Course/credit distribution (Credits 2)	Course/ credit distribution (Credits 2)	Course/ credit distribution (Credits 2)	22
I	DSC A(Botany) 1- (4) DSC B (Zoology) 1- (4) DSC C (Chemistry)1- (4) (3T+1L)		Choose one from a pool of courses GE – 1 (4)	AEC – 1 (2)	Choose one from a pool of courses SEC – 1 (2)		Choose one from a pool of courses VAC – 1 (2)	22
II	DSC A(Botany) 2- (4) DSC B (Zoology) 2- (4) DSC C (Chemistry)2- (4) (3T+1L)		Choose one from a pool of courses GE – 2 (4)	AEC – 2 (2)	Choose one from a pool of courses SEC – 2 (2)		Choose one from a pool of courses VAC – 2 (2)	22

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<b>Students on exit shall be awarded Undergraduate Certificate (in the field of Multidisciplinary study) after securing requisite 44 credits in semester I &amp; I</b>						Total = 44
III	DSC A(Botany) 3- (4) DSC B (Zoology) 3- (4) DSC C (Chemistry)3- (4) (3T+1L)	Choose one from a pool of courses, DSE A/B/C (4) OR GE - 3 (4) (4 T/or 3T+1L/or 2T+2L) OR MOOC	AEC - 3 (2)	Choose one from SEC 3 - (2)  OR Internship/Apprenticeship / Project/ Community Outreach (IAPC) - (2)	Choose one from a pool of courses VAC - 3 (2)	22
IV	DSC A(Botany) 4- (4) DSC B (Zoology) 4- (4) DSC C (Chemistry)4- (4) (3T+1L)	Choose one from a pool of courses, DSE A/B/C (4) credits) OR GE - 4 (4) (4 T/or 3T+1L/or 2T+2L) OR MOOC	AEC - 4 (2)	Choose one from SEC 4 - (2)  OR Internship/Apprenticeship / Project/ Community Outreach (IAPC) - (2)	Choose one from a pool of courses VAC - 4 (2)	22
<b>Students on exit shall be awarded Undergraduate Diploma (in the field of Multidisciplinary study/Discipline) after securing requisite 88 credits in semester III &amp; IV</b>						Total = 88
V	DSC A (Botany) 5- (4) DSC B (Zoology) 5- (4) DSC C (Chemistry)5- (4) (3T+1L)	Choose one from a pool of courses, DSE A/B/C (4) credits) ( 3T+1L/or 2T+2L) OR MOOC	Choose one from a pool of courses GE - 5 (4) OR MOOC		Choose one from SEC 5 - (2)  OR Internship/Apprenticeship / Project/ Community Outreach (IAPC) - (2)	22
VI	DSC A (Botany) 6- (4) DSC B (Zoology) 6- (4) DSC C (Chemistry)6- (4) (3T+1L)	Choose one from a pool of courses, DSE A/B/C (4) credits) ( 3T+1L/or 2T+2L) OR MOOC	Choose one from a pool of courses GE - 6 (4) OR MOOC		Choose one from SEC 5 - (2)  OR Internship/Apprenticeship / Project/ Community Outreach (IAPC) - (2)	22
<b>Students on exit shall be awarded Bachelor of Science (in the field of Multidisciplinary study/Discipline) after securing requisite 132 credits on completion of semester VI</b>						Total= 132
VII	DSC A/B/C 7 - (4)  (3T+1L)	Choose 3 DSE (3x4) courses OR Choose 2 DSE - (2x4) and one GE (4) course OR Choose 1 DSE (4) and 2 GE (2x4) courses (Total= 12)		Dissertation on Major/Minor (4+2) OR Academic Project/ Entrepreneurship (4+2)		22
VIII	DSC A/B/C 8 - (4)  (3T+1L)	Choose 3 DSE (3x4) courses OR Choose 2 DSE - (2x4) and one GE (4) course OR Choose 1 DSE (4) and 2 GE (2x4) courses		Dissertation on Major/Minor (4+2) OR Academic Project/ Entrepreneurship (4+2)		22

(Total= 12)

**Students on exit shall be awarded Bachelor of Science (in the field of Multidisciplinary study/Discipline) (Honours with Research or Honours with Academic project/Entrepreneurship) after securing the requisite 176 credits on completion of semester VIII**

Total =  
176

### Course Introduction:

The new curriculum of B.Sc. with Botany, Zoology, and Chemistry as core disciplines offers a one-year Undergraduate certificate, two-year Undergraduate diploma three-year Undergraduate degree, and four-year Undergraduate degree (Hons. with Research) after securing the required credits as per the Curriculum and credit framework for Undergraduate program guidelines by UGC.

B.Sc. (Discipline specific core A - Botany) offers the essential knowledge and technical skills to study plants in a holistic manner. Students would be trained in all areas of plant biology using a unique combination of core, elective, and skill papers with significant interdisciplinary components. Students would be exposed to cutting-edge technologies currently being used in studying plant life forms, their evolution, and interactions with other organisms within the ecosystem. Students would also become aware of plants' social and environmental significance and relevance to the national economy.

B.Sc. (Discipline specific core A - Botany) covers academic activities within the classroom sessions along with practical concepts in laboratory sessions. Outstation activities and projects would also be organized for real-life experience and learning. Candidates who have curiosity in plants kingdom, and ecosystems, love exploring exotic places, and wish to work as researchers or professionals like botanists, conservationists, Ecologists, etc. can choose B.Sc. Course.

**Eligibility for admission:** Any candidate who has passed the Plus Two of the Higher Secondary Board of Examinations in any state recognized as equivalent to the Plus Two of the Higher Secondary Board in with PCB not less than 45%-marks in aggregate is eligible for admission, However, SC/ST, OBC and other eligible communities shall be given relaxation as per University rules

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**Program Outcomes (POs):**

A transformed curriculum shall develop educated outcome-oriented candidature, fostered with discovery-learning, equipped with practice & skills to deal with practical problems, and versed with recent pedagogical trends in education including e-learning, flipped class, and hybrid learning to develop into responsible citizen for nation-building and transforming the country towards the future with their knowledge gained in the field of plant science.

PO-1	Bachelor of Science offers theoretical as well as practical knowledge about different subject areas.
PO-2	Graduates will develop a scientific temperament to solve scientific problems in emerging areas of science at National and International levels.
PO-3	Graduates will acquire a coherent understanding of the academic field to pursue multi and interdisciplinary science careers in the future.
PO-4	Graduates will have clarity of thought and expression. Qualities like logical thinking and decision-making will be enhanced
PO-5	Graduates plan and execute experiments or investigations, analyze and interpret data information collected using appropriate methods
PO-6	Graduates will be able to compete in various national and international competitive examinations.
PO-7	Graduates will understand the principles of basic and applied sciences and apply them logically in environmental and socio-technological contexts with a systematic approach toward sustainable development.
PO-8	Graduates will have critical thinking, follow innovations and developments in Science and technology
PO-9	Graduates will acquire effective communication skills
PO-10	Graduates will understand ethical principles and responsibilities for effective citizenship.
PO-11	Graduates will develop new and enhancing conversational skills that lead not only to good communication but also to excellent drafting abilities linked with technical reports and presentations.
PO-12	Graduates will be competent enough for doing jobs in Govt. and private sectors of academia, research, and industry.

**Program-specific outcomes (PSOs): Undergraduate certificate in B.Sc.**

- This certificate course will provide knowledge of various fields of basic Botany.
- The syllabus is prepared to enable students for competitive exams in frontier areas of plant sciences.
- Students will be able to know about the habits, habitat, morphology, anatomy, and reproduction of various plant groups.

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**Program-specific outcomes (PSOs): Undergraduate Diploma in B.Sc.**

- This program will provide knowledge of plant anatomy, embryology, and Cytogenetics.
- Laboratory sessions following theory will provide an easy understanding of the internal structure of various plant parts, structural organization, reproductive biology, and genetics.
- This course will help students to become plant morphologists

**Program-specific outcomes (PSOs): Undergraduate Degree in B.Sc.**

- The three-year learning outcome of graduation will provide an understanding of plant systematics, developmental biology, ecology, statistics, physiology, biochemistry, anatomy, and plant genetics.
- It will provide expertise in conservation biology and reproduction biology.
- After completing this course successfully students will be able to contribute in the field of plant sciences. The research project will help to develop research aptitude for higher education and scientific research.

**Program-specific outcomes (PSOs): B.Sc. (Hons) Research**

- The four-year program help students to pursue a career as Nursery managers, ecologist, and conservationist in many firms, Plant explorer in governmental and non-governmental organizations, park ranger, good researcher, plant pathologists, a microbiologist, and breeding scientist in national laboratories.
- It is beneficial for students that they can work in different industries and National institutes and organizations for the demand of society and for sustainable utilization

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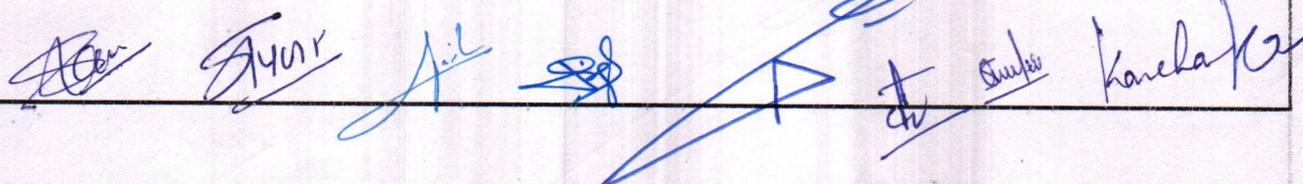
## COURSE STRUCTURE

### Semester Wise Discipline Specific Core

Semester	Course Type	Course Code	Course Title	L	T	P	C
I	DSC-A (Botany)	BOTDC101	Microbes, Algae, Fungi, and Bryophytes	3	0	0	3
		BOTDL102	Practical/Lab Course	0	0	2	1
II		BOTDC201	Pteridophytes, Gymnosperms, and Angiosperms	3	0	0	3
		BOTDL202	Practical/Lab course	0	0	2	1
III		BOTDC301	Morphology and Anatomy	3	0	0	3
		BOTDL302	Practical/Lab course	0	0	2	1
IV		BOTDC401	Embryology and Cytogenetics	3	0	0	3
		BOTDL402	Practical/Lab course	0	0	2	1
V		BOTDC501	Economic Botany and Plant Breeding	3	0	0	3
		BOTDL502	Practical/Lab course	0	0	1	2
VI		BOTDC601	Physiology and Biochemistry	3	0	0	3
		BOTDL602	Practical/Lab course	0	0	1	2
VII		BOTDC701	Mycology and Microbiology	3	0	0	3
		BOTDL702	Practical/Lab Course	0	0	2	1
VIII		BOTDC801	Palynology and Pollination Biology	3	0	0	3
		BOTDL802	Practical/Lab Course	0	0	2	1

### Semester Wise Discipline-Specific Elective

Semester	Course Type	Course Code	Course Title	L	T	P	C
V	DSE-A (Botany)	BOTDE503	Cell and Molecular Biology & Plant Biotechnology	3	0	0	3
		BOTDL504	Practical/Lab course	0	0	2	1
VI		BOTDE603	Ecology and Biostatistics	3	0	0	3
		BOTDL604	Practical/Lab course	0	0	2	1
VII		BOTDE703	Plant Resource Utilization and Conservation	3	0	0	3
		BOTDL704	Practical/Lab course	0	0	2	1
		BOTDE705	Research Methodology	3	0	0	3
		BOTDL706	Practical/Lab course	0	0	2	1
		BOTDE707	Taxonomy and Diversity of Flowering Plants	3	0	0	3
VIII		BOTDL708	Practical/Lab course	0	0	2	1
	BOTDE803	Plant Health Management	3	0	0	3	
	BOTDL804	Practical/Lab course	0	0	2	1	
	BOTDE805	Genetics, Plant Breeding and IPR	3	0	0	3	



		BOTDL806	Practical/Lab course	0	0	2	1
		BOTDE807	Freshwater algal flora of Himalaya	3	0	0	3
		BOTDL808	Practical/Lab course	0	0	2	1

### Semester Wise Generic Elective

Semester	Course Type	Course Code	Course Title	L	T	P	C
I	GE-A (Botany)	BOTGE103	Plant Science-I	4	0	0	4
II		BOTGE203	Plant Science-II	4	0	0	4
III		BOTGE303	Plant Science-III	4	0	0	4
IV		BOTGE403	Plant Science-IV	4	0	0	4
V		BOTGE505	Medicinal Plant Diversity of Uttarakhand	4	0	0	4
VI		BOTGE605	Global Climate Change	4	0	0	4

### Semester Wise Ability Enhancement Course

Semester	Course Type	Course Code	Course Title	L	T	P	C
I	AEC	AEC-104	Environment Science-I	2	0	0	2
II		AEC-204	Environment Science-II	2	0	0	2
III		AEC-304	English Communication-I	2	0	0	2
IV		AEC-404	English Communication-II	2	0	0	2

### Semester Wise Skill Enhancement Course/IAPC

Semester	Course Type	Course Code	Course Title	L	T	P	C
I	SEC-A/IAPCA (Botany)	BOTSC105	Nursery and Gardening	2	0	0	2
II		BOTSC205	Conservation and Management of Biodiversity	2	0	0	2
III		BOTSC305	Biofertilizers OR Internship/Apprenticeship / Project/ Community Outreach/MOOC.	2	0	0	2
IV		BOTSC405	Ethnobotany OR Internship/Apprenticeship / Project/ Community Outreach/ OR MOOC.	2	0	0	2
V		BOTSC506	Mushroom Cultivation OR Internship/Apprenticeship / Project/ Community Outreach/ OR MOOC	2	0	0	2
VI		BOTSC606	Herbal Technology OR Internship/Apprenticeship / Project/ Community Outreach/ OR MOOC	2	0	0	2

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**Semester Wise Dissertation**

Semester	Course Type	Course Code	Course Title	L	T	P	C
VII	IAPC	BOTDT709	Dissertation on Major Core/Minor Elective (from VII Semester papers) OR Academic Project/ Entrepreneurship				6
VIII	IAPC	BOTDT809	Dissertation on Major Core/Minor Elective (from VIII Semester papers) OR Academic Project/ Entrepreneurship				6



**Discipline Specific Core  
Semester-I  
Microbes, Algae, Fungi, and Bryophytes  
BOTDC101**

**Course Outcome**

After the completion of the course, the students will be able to:

1. Remember: Define, Recall, select, and recognize the diversity of different microbes including viruses, Algae, Fungi, bryophytes & Lichens & their economic importance.
2. Understanding: Develop, describe, classify, and discuss understanding about the classification and diversity of different microbes including viruses, Algae, Fungi & Lichens & their economic importance, and the structure and reproduction of certain selected bacteria, algae, fungi, bryophytes, and lichens
3. Apply: Explain the morphology, anatomy, and reproduction of Bryophytes. Thallus organization, classification, vegetative structure, and Life cycles of microbes, algae & fungi, and bryophytes.
4. Analyzing: Explain, differentiate, or classify conceptual skills about identifying microbes, pathogens, Biofertilizers & lichens.
5. Evaluating: Summarize, distinguish, or conclude knowledge about developing commercial enterprise of microbial products. Host-pathogen relationship and disease management.
6. Creating: Construct, develop, generalize, prepare, and write about the uses of microbes, fungi, algae, and lichens in various fields

Unit	Topic	No. of lectures/ hrs (45)
1	<b>Microbes :</b> Viruses-discovery, general structure, replication (general account), DNA virus (T-phage); Lytic and lysogenic cycle, RNA virus (TMV); economic importance; bacteria-discovery, general characteristics, and cell structure; reproduction- vegetative, asexual and recombination (conjugation, transformation and transduction); economic importance.	10
2	<b>Algae:</b> General characteristics; Range of Thallus organization and reproduction; classification of algae; morphology and life-cycles of <i>Nostoc</i> , <i>Chlamydomonas</i> , <i>Oedogonium</i> , <i>Vaucheria</i> , <i>Fucus</i> , <i>Sargassum</i> ; economic importance of algae.	10



### Suggested reading

- Kumar, H.D. (1999). Introductory Phycology. Affiliated East-West. Press Pvt. Ltd. Delhi. 2<sup>nd</sup> edition.
- Tortora, G.J., Funke, B.R., Case, C.L. (2010). Microbiology: An Introduction, Pearson Benjamin Cummings, U.S.A. 10<sup>th</sup> edition.
- Sethi, I.K. and Walia, S.K. (2011). Text book of Fungi and Their Allies, MacMillan Publishers Pvt. Ltd., Delhi.
- Alexopoulos, C.J., Mims, C.W., Blackwell, M. (1996). Introductory Mycology, John Wiley and Sons (Asia), Singapore. 4<sup>th</sup> edition.
- Raven, P.H., Johnson, G.B., Losos, J.B., Singer, S.R. (2005). Biology. Tata McGraw Hill, Delhi, India.
- Pandey, S.N and Trivedi, P.S. (2015). A text book of Botany Vol.I Vikas publishing House Pvt/ Ltd, New Delhi.
- Vashishta, P.C., Sinha, A.K., Kumar, A. (2010). Bryophyta, S. Chand. Delhi, India.
- Parihar, N.S. (1991). An Introduction to Embryophyta Vol. I Bryophyta. Central Book Depot, Allahabad.

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**Practical/Lab Course  
BOTDL102**

**Course Outcomes:**

After the completion of the course, the students will be able:

1. To remember the instruments, techniques, lab etiquettes, and good lab practices for working in a microbiology laboratory.
2. Understand morphology, anatomy, reproduction, and developmental changes therein through typological study and create a knowledge base in understanding diversity, economic values & taxonomy of bryophytes.
3. Apply practical skills in the field and laboratory experiments in Microbiology and Pathology.
4. Analyze skills for identifying microbes and using them for Industrial, Agriculture, and Environment purposes.
5. Evaluate to identify algae, lichens, and plant pathogens along with their symbiotic and parasitic associations.
6. Students would learn to create their small digital reports where they can capture the zoomed-in and zoomed-out pictures as well as videos in case they are able to find some rare structure or phenomenon related to Bryophytes.

Unit	Topic	No. of Lectures/ hrs (60)
1	Ems/Models of Viruses – T-Phage and TMV, Line drawing/Photograph of Lytic and Lysogenic Cycle. Types of Bacteria from temporary/permanent slides/photographs; EM of bacterium; Binary Fission; Conjugation; Structure of root nodule; Gram staining technique	15
2	Study of vegetative and reproductive structures of <i>Nostoc</i> , <i>Chlamydomonas</i> (electron micrographs), <i>Oedogonium</i> , <i>Vaucheria</i> , <i>Fucus</i> , and <i>Sargassum</i> through temporary preparations and permanent slides/specimens	15
3	<i>Rhizopus</i> and <i>Penicillium</i> : Asexual stages from temporary mounts. <i>Alternaria</i> : Specimens/photographs and tease mounts. <i>Puccinia</i> : Herbarium specimens of Black Rust of Wheat and infected Barberry leaves; section/tease mounts of spores on wheat and permanent slides of both the hosts. <i>Agaricus</i> : Specimens of button stage and full-grown mushroom. Lichens: Study of growth forms of lichens (crustose, foliose, and fruticose). Mycorrhiza: ecto mycorrhiza and endo mycorrhiza (Photographs).	15

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4	<p><i>Marchantia</i> and <i>Riccia</i>: Morphology of thallus, rhizoids, and scales, V.S. 13iofert through gemma cup, gemmae whole mount (all temporary slides), V.S antheridiophore, archegoniophore, L.S. sporophyte (all permanent slides).</p> <p><i>Funaria</i>- Morphology, whole mount leaf, rhizoids, operculum, peristome, annulus, spores (temporary slides); permanent slides showing antheridial and archegonial heads, L.S capsule, and protonema.</p>	15
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Suggested reading

- Pandey, B.P. (2014). Modern Practical Botany Vol. I. S. Chand and Company Ltd. Ramnagar, New Delhi.
- Purohit, S.D., Kundra, G. K. and Singhvi, A. (2013). Practical Botany (part I). Apex Publishing House Durga Nursery Road Udaipur, Rajasthan.
- Sambamurty, A.V.S.S. (2006). A textbook of algae. I.K International Publishing House, Pvt. Ltd.

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**Semester-II**  
**Pteridophytes, Gymnosperms, and Angiosperms**  
**BOTDC201**

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

1. Remember: Define, Recall, select, and recognize the diversity of different plants including biofertilizers, and gymnosperms. Angiosperms and their economic importance.
2. Understand: Develop a critical understanding of morphology, anatomy, and reproduction of Pteridophytes, Gymnosperms, and Angiosperms. Understanding of plant evolution and their transition to land habitat.
3. Apply: learn the major patterns of diversity among plants, and the characters and types of data used to classify plants.
4. Analyze: compare the different approaches to classification with regard to the analysis of data.
5. Evaluate: major taxa and their identifying characteristics, and develop in-depth knowledge of the current taxonomy of a major plant family.
6. Create: To discover and use diverse taxonomic resources, reference materials, herbarium collections, and publications.

Unit	Topic	No. of Lectures/ hrs (45)
1	<b>Pteridophytes</b> General characteristics, classification, early land plants ( <i>Rhynia</i> ); classification (up to family), morphology, anatomy, and reproduction of <i>Selaginella</i> , <i>Equisetum</i> , and <i>Pteris</i> ; heterospory and seed habit, stellar evolution; ecological and economic importance of Pteridophytes.	10
2	<b>Gymnosperms</b> General characteristics, classification (up to family), morphology, anatomy, and reproduction of <i>Cycas</i> , <i>Pinus</i> , and <i>Ephedra</i> ; ecological and economic importance.	10
3	<b>Introduction to plant taxonomy</b> Identification, classification, nomenclature, functions of herbarium, important herbaria and botanical gardens of the world and India Important flora, botanical nomenclature (principles and rules (ICN); ranks and names; binominal system, typification, author citation, valid publication, rejection of names, the principle of priority and its limitations). Classification: Types of classification-artificial, natural, and phylogenetic Bentham and Hooker (upto series) and Hutchinson classification.	10
4	<b>Taxonomy of plant families:</b> Ranunculaceae, Malvaceae, Rutaceae, Fabaceae, Apiaceae, Solanaceae, Lamiaceae, Euphorbiaceae, Asteraceae, Poaceae, and Orchidaceae ( <b>Families can be chosen as per the availability of local flora</b> )	15

### Suggested readings

- Vashishta, P.C., Sinha, A.K. and Kumar, A. (2016). Pteridophyta, S Chand and Company Ltd., Ramnagar, New Delhi, India.
- Vashishta, P.C., Sinha, A.K. and Kumar, A. (2016). Gymnosperms, S Chand and Company Ltd., Ramnagar, New Delhi, India.
- Bhatnagar, S.P. and Moitra, A. (1996). Gymnosperms. New Age International (P) Ltd Publishers, New Delhi, India.
- Parihar, N.S. (1991). An Introduction to Embryophyta. Vol. I. Bryophyta. Central Book Depot, Allahabad.
- Simpson, M.G. (2006). Plant Systematics. Elsevier Academic Press, San Diego, CA, U.S.A.
- Singh, G. (2018). Plant Systematics: Theory and Practice. Oxford and IBH Pvt. Ltd., New Delhi. 3<sup>rd</sup> edition.
- Gangulee H.C., Kar, A.K. and Santra S.C. (2011). College Botany Vol II. 4<sup>th</sup> Edition New Central Book Agency.
- Parihar, N.S. (1976). Biology and Morphology of Pteridophytes. Central Book Depot.
- Sharma, O.P. (1990). Textbook of Pteridophyta. MacMillan India Ltd. Delhi.
- Pandey, B.P. (2010). College Botany Vol II. S. Chand and Company Ltd., New Delhi, India.

*Ram* *Anur* *Ajit* *SS* *A* *Suraj* *Kanchan* *Kal*

**Practical/Lab Course**  
**BOTDL202**

**Course Outcomes:**

1. Remember to aware of the group of plants that have given rise to land habit and the flowering plants.
2. Understand morphology, reproduction, and developmental changes therein through typological study
3. Apply through field study they will be able to see these plants growing in nature and become **familiar with the biodiversity**.
4. Analyze by observation and table study of representative members of phylogenetically important groups to learn the process of evolution in a broad sense.
5. Evaluate a knowledge base in understanding the basis of plant diversity, economic values & taxonomy of plants.
6. Create: To discover and use diverse taxonomic resources, reference materials, herbarium collections,

Unit	Topic	No. of Lectures/ hrs (60)
1	<p><i>Selaginella</i>: Morphology, whole mount leaf with a ligule, strobilus, microsporophyll, and megasporophyll (temporary slides), T.S. stem, L.S. strobilus (permanent slide).</p> <p><i>Equisetum</i>: Morphology, T.S. internode, L.S. strobilus, T.S and L.S. strobilus, whole mount sporangiophore, spores (wet and dry) (temporary slides); T.S. rhizome (permanent slide).</p> <p><i>Pteris</i>: Morphology, T.S rachis, V.S. sporophyll, whole mount Sporangium and spores (temporary slides), T.S. rhizome, whole mount prothallus with sex organs and young sporophyte (permanent slide).</p>	15
2	<p><i>Cycas</i>: Morphology (coralloid roots, bulbil, leaf), T.S. coralloid root and rachis, V.S. leaflet and microsporophyll, whole mount spores (temporary slides), L.S. ovule, T.S. root (permanent slide).</p> <p><i>Pinus</i>: Morphology (long and dwarf shoots, male and female cones), T.S. needle and stem, L.S. /T.S. male cone, whole mount microsporophyll and microspores (temporary slides), L.S. female cone, TLS, and RLS stem (permanent slide).</p>	15
3	<p><b>Taxonomic Identification:</b> Description of a plant, the study of vegetative and floral characters (description, V.S. flower, a section of ovary, floral diagram/s, floral formula/e) and systematic position of the</p>	15

	Following families according to Bentham and Hooker's system of classification: Brassicaceae, Asteraceae, Solanaceae, Lamiaceae, and Liliaceae. ( <b>Plants can be chosen as per the availability of local flora</b> )	
4	<b>Herbarium techniques:</b> Plant collection, preservation, and mounting of two properly dried and pressed specimens of any wild plant with herbarium label (to be submitted in the record book), digital/virtual herbarium.	15

#### Suggested readings

- Pandey, B.P. (2014). Modern Practical Botany Vol. II. S. Chand and Company Ltd., New Delhi.
- Bendre, A.M. and Kumar A. (2003). Manual of Practical Botany Vol. II. Rastogi Publications, Meerut.
- Santra S.C. and Chatterjee (2005). College Botany Practical Vol. II New Central Book Agency Pvt. Ltd.

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**Semester-III**  
**Morphology and Anatomy**  
**BOTDC301**

**Course Outcomes:**

1. Remember the terms associated with the morphology and anatomy of plants.
2. Understand the morphology and anatomy of plants and the role of tissues in plant functions.
3. Apply to explain and write about Vascular cambium – structure and function, seasonal activity. Secondary growth, Epidermis, cuticle, stomata.
4. Analyze the vegetative characteristics of the plant, various tissue systems; the normal and anomalous secondary growth in plants, and their causes.
5. Evaluate the composition, modifications, internal structure & architecture of plants.
6. Create a digital herbarium and prepare the flora of locally available plants

Unit	Topic	No. of Lectures/ hrs (45)
1	<b>Meristematic and permanent tissues:</b> Types of tissues, Root and shoot apical meristems, Theories related to apical meristem, simple, complex and secretory tissues	10
2	<b>Organs:</b> Structure of dicot and monocot root, stem and leaf, root stem Transition	10
3	<b>Adaptive and protective systems:</b> Epidermis, cuticle, and stomata	5
4	<b>Secondary growth:</b> Structure and function of Vascular cambium, secondary growth in stem and roots, abnormal secondary growth	10

**Suggested readings**

- Mauseth, J.D. (1988). Plant Anatomy. The Benjamin/Cummings Publisher, USA.
- Pandey, B.P. (2001) Plant Anatomy. S. Chand and Company Ltd., New Delhi.
- Sharma, P.C. (2017). Text Book of Plant Anatomy. Arjun Publishing House.
- Menan, A.B. (2008). Introduction to Plant Anatomy. Neha Publishers and Distributors.
- Sharma, M.K. (2013) Plant Structures (An Introduction to Plant Anatomy). Vayu Education of India.

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**Practical/Lab Course  
BOTDL302**

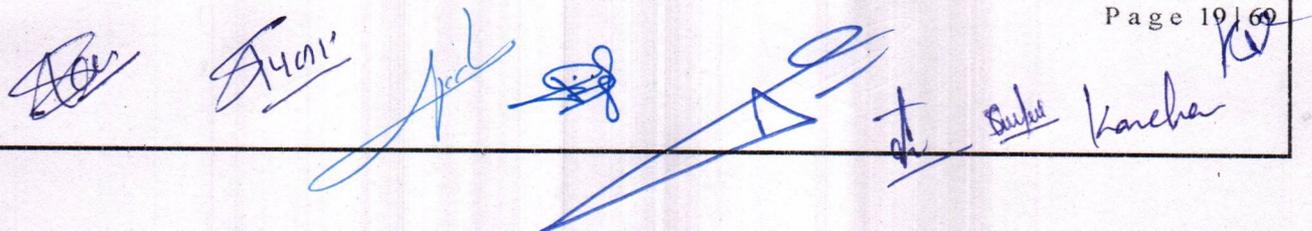
**Course outcomes:**

1. Remember the terms associated with the morphology and anatomy of plants.
2. Understand cell structure in monocot and dicot plants.
3. Apply to explain and write about Vascular cambium – structure and function, seasonal activity. Secondary growth, Epidermis, cuticle, stomata.
4. Analyze cell structure, secondary growth, and adaptive anatomy in plants.
5. Evaluate the composition, modifications, internal structure & architecture of plants.
6. Create a digital herbarium and prepare the flora of locally available plants

Unit	Topic	No. of Lectures (60 hrs)
1	Study of meristems through permanent slides and photographs. Tissues (parenchyma, collenchyma and sclerenchyma), complex and secretory tissues	15
2	Anatomy of monocot and dicot Stem; monocot and dicot leaf; monocot and dicot root ( <b>Plants can be chosen as per availability of local flora</b> )	15
3	Adaptive anatomy: Xerophytes, Hydrophytes, Epiphytes ( <b>Plants can be chosen as per availability of local flora</b> )	15
4	Normal and abnormal secondary growth in different plants ( <b>Plants can be chosen as per availability of local flora</b> )	15

Suggested readings

- Pandey, B.P. (2014). Modern Practical Botany Vol. II. S. Chand and Company Ltd. Ramnagar, New Delhi.
- Pandey, B.P. (2001). Plant Anatomy. S. Chand and Company Ltd., Ram Nagar, New Delhi.
- Sundara, R.S. (2002). Practical Manual Anatomy and Embryology. Anmol Publisher, New Delhi.



**Semester-IV**  
**Embryology and Cytogenetics**  
**BOTDC401**

**Course Outcomes:**

1. Remember the principles and details of using light and electron microscopes and the role of X-ray diffraction in studying the structures of cellular organelles and biomolecules and defining various types of cell organelles and their functions. Properties of hereditary, Sex-determination, and Sex-linked Inheritance Linkage and Crossing over.
2. Understand reproduction and developmental changes in plants. Structure and chemical composition of chromatin and concept of cell division.
3. Apply Mendel's principles; acquire knowledge on cytoplasmic inheritance and sex-linked inheritance. Mutations and Chromosomal Aberrations,
4. Analyze to distinguish the Endosperm types, structure, and functions; Dicot and monocot embryo; Embryo- endosperm relationship.
5. Evaluate to summarize and justify about Pollination mechanisms and adaptations; Double fertilization; Seed- structure appendages and dispersal mechanisms.
6. Create to develop, construct or write about the Apomixis and polyembryony with their practical applications.

Unit	Topic	No. of Lectures (45 hrs)
1	<b>Pollination and fertilization:</b> Pollination mechanisms and adaptation, the structure of anther and pollen, development of male and female gametophytes, double fertilization.	10
2	<b>Embryo and endosperm:</b> Types of ovules and embryo sacs; embryo and endosperm; types of endosperm; dicot and monocot embryo; Apomixis and polyembryony.	10
3	<b>Heredity:</b> (Pre-mendelian genetics, brief life history of Mendel, laws of Inheritance, modified Mendelian ratios, lethal genes, co-dominance, incomplete dominance, chi-square, pedigree analysis, multiple allelism, chromosome theory of inheritance, sex-determination and sex-linked inheritance, cytoplasmic inheritance <b>Linkage and crossing over</b> Linkage: concept and history, complete and incomplete linkage, bridges experiment, coupling and repulsion, recombination frequency, linkage maps based on two and three-factor Crosses.	15

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4	<b>Crossing over:</b> Concept and significance, cytological proof of crossing over; mutations and chromosomal aberrations (types of mutations, effects of physical and chemical mutagens, numerical chromosomal changes: euploidy, polyploidy and aneuploidy; structural chromosomal changes: deletions, duplications, inversions and translocations).	10
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Suggested readings

- Bhojwani, S.S. and Bhatnagar, S.P. (2010). The Embryology of Angiosperms. Vikas Publication House Pvt. Ltd. New Delhi. 5<sup>th</sup> edition.
- Johri, B.M. (1984). Embryology of Angiosperms. Springer-Verlag, Berlin
- Maheshwari, P. (1971). An Introduction to Embryology of Angiosperms. McGraw Hill Book Co. London.
- Rastogi, V.B. (2019). Genetics. 4<sup>th</sup> Edition. MEDTECH: A Division of Scientific International.

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**Practical/Lab Course  
BOTDL402**

**Course Outcomes:**

1. Remember the principles and details of using light and electron microscopes and the role of X-ray diffraction in studying the structures of cellular organelles and biomolecules and defining various types of cell organelles and their functions. Understand the pollination and seed dispersal mechanism.
2. Understand to study the structure of ovules and female gametophytes.
3. Apply Mendel's principles; and understand the monohybrid and dihybrid crosses and their ratio and chromosomal changes.
4. Analyze to explain the types of ovules: anatropous, orthotropous, circinotropous, amphitropous, and campylotropous. Female gametophyte: *Polygonum* (monosporic) type of embryo sac development (permanent slides/photographs) Ultrastructure of mature egg apparatus cells through electron micrographs (permanent slides/photographs).
5. Evaluate the problems of Incomplete dominance and gene interaction through seed ratios.
6. Create the idea of polyploidy conditions in plants.

Unit	Topic	No. of Lectures (60 hrs)
1	Pollination types and seed dispersal mechanisms (photographs and specimens)	15
2	Structure of anther (young and mature). Types of ovules: anatropous, orthotropous, circinotropous, amphitropous, campylotropous. Female gametophyte: <i>Polygonum</i> (monosporic) type of embryo sac development (permanent slides/photographs) Ultrastructure of mature egg apparatus cells through electron micrographs (permanent slides/photographs)	15
3	Mendel's laws through seed ratios. Laboratory exercises in probability and chi-square. Monohybrid cross (dominance and incomplete dominance) Dihybrid cross and gene interactions Pedigree analysis for dominant and recessive autosomal and sex-linked traits. Incomplete dominance and gene interaction through seed ratios (9:7, 9:6:1, 13:3, 15:1, 12:3:1, 9:3:4).	15
4	Study of aneuploidy: Down's, Klinefelter's and Turner's syndromes through photographs. Photographs/permanent slides showing translocation ring, laggards, and inversion bridge	15

**Suggested Reading**

- Sundara, R.S. (2002). Practical Manual Anatomy and Embryology. Anmol Publisher, New Delhi.
- Singh, R.J. (2021). Practical Manual on Plant Cytogenetics. CRC Press, Taylor and Francis Group, Routledge.

**Semester-V**  
**Economic Botany and Plant Breeding**  
**BOTDC501**

**Course Outcomes:**

1. Remember the role of plants in human welfare. Students will be able to gain the knowledge of Origin of Cultivated Plants, Cereals, Legumes, Spices, Oils and Fats, Fiber Yielding Plants, Medicinal Plants, Plant Breeding, Methods of crop improvement, Inbreeding depression, and heterosis.
2. Understand the economic uses of various plants and the important objectives of plant breeding.
3. Apply methods of crop improvement.
4. Analyze the economically useful plants.
5. Summarize the procedure, advantages, and limitations of various crop improvement methods used for self-pollinated, cross-pollinated vegetatively propagated crops.
6. Develop the knowledge of plant parts used in medical form, beverage form, Fodder, Forage form, etc

Unit	Topic	No. of Lectures (45 hrs)
1	Origin of cultivated plants (concept of centers of origin, their importance with reference to Vavilov's work)	5
2	A brief knowledge of botany and commercial utilization and uses of the following plants: Cereals and millets- Wheat, Rice and Maize, Ragi, Pearl millet; Sugar yielding plants- Sugarcane and Sugar beet; Fruits- Mango, Apple, Banana, Citrus and Litchi.; Fibers- Cotton, Jute, Hemp, Coir, Agave and Semal.; Vegetables- Root vegetables, stem vegetables and fruit vegetables.; Timbers- Teak, Shisham, Sal, Chir and Deodar; Medicinal plants- <i>Aconitum</i> , <i>Atropa</i> , <i>Cinchona</i> , <i>Rauwolfia</i> , <i>Ephedra</i> , <i>Withania</i> , and <i>Alovera</i> ; Oils, Beverages, Fumitories, masticatories, Spices and Condiments yielding plants.	15
3	Plant breeding (introduction and objectives; breeding systems, important achievements and undesirable consequences of plant breeding); methods of crop improvement; centres of origin and domestication of crop plants, plant genetic resources; acclimatization; selection methods.	10
4	Hybridization: for self, cross and vegetatively propagated plants –procedure, advantages and limitations; inbreeding depression and heterosis (history, genetic basis of inbreeding depression and heterosis; applications); crop improvement and breeding (role of mutations; polyploidy; distant hybridization and role of biotechnology in crop improvement).	15

**Suggested readings**

- Kochhar, S.L. (2015). Economic Botany in the Tropics, MacMillan Publishers India Ltd., New Delhi. 4<sup>th</sup> edition.
- Pandey, B.P. (1999). Economic Botany. S. Chand, New Delhi.
- Singh, B.D. (2005). Plant Breeding: Principles and Methods. Kalyani Publishers. 7<sup>th</sup> edition.
- Acquaah, G. (2007). Principles of Plant Genetics and Breeding. Blackwell Publishing

**Practical/Lab Course  
BOTDL502**

**Course Outcomes:**

1. Remember the terms associated with economic botany and plant breeding
2. Understand the details of economic plants.
3. Apply the different techniques for breeding programs.
4. Analyze the chemistry of plants and herbal preparations.
5. Evaluate the diversity of economically important plants.
6. Create a Germplasm conservation strategy for future use.

Unit	Topic	No. of Lectures (60 hrs)
1.	Study of economically important plants: Cereals: Wheat, Rice, Maize; Millets: Finger millet, Foxtail, Ragi; Pulses: Gram, Green gram, Pea, Pigeon pea, Soyabean, Chickpeaa; Timbers: Shisam, Sal; Teak, Deodar, Pine	15
2.	Medicinal plants: Dhatura, Berginia, Hedychium, Poppy, Basil, Barberry; Beverages: Tea, Coffee; Oils: Mustard, Sesame, Coconut, Linseed, Groundnut, Castor, Laung, Sandalwood, mentha; Spices: Coriander, Cardmum, Curcuma, Cinamom, Laung, Cumin, Thyme, Nigella, Cinamom leaf	15
3	Fibers: Jute, Coconut, Hemp, Urtica, Cotton; Sugars and starch yielding plants: Sugarcane, Potato, Beetroot Fruits and vegetables cultivated in the area. Gums and Resins.	15
4	Hybridization techniques – Emasculation, Bagging (For demonstration only). Induction of polyploidy in plants (For demonstration only).	15

**Suggested readings**

- Kochhar, S.L. (2011). Economic Botany in the Tropics, MacMillan Publishers India Ltd., New Delhi. 4<sup>th</sup> edition.
- Pandey, B.P. (1999). Economic Botany. S. Chand, New Delhi.
- Singh, B.D. (2005). Plant Breeding: Principles and Methods. Kalyani Publishers. 7<sup>th</sup> edition.
- Acquaah, G. (2007). Principles of Plant Genetics and Breeding. Blackwell Publishing.

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**Semester-VI**  
**Plant Physiology and Biochemistry**  
**BOTDC601**

**Course Outcomes:**

1. Remember the concept of water potential, diffusion, osmosis and Imbibition, Energy flow, Biomolecules, photosynthesis, metabolism, nitrogen fixation, translocation, and Phytohormones.
2. Understand the plants and plant cells in relation to water, nutrition, photosynthetic pathways, and respiration.
3. Apply: Explain the structure, composition, and functional mechanisms of various biologically important molecules like carbohydrates, amino acids, proteins and lipids, photosynthesis, respiration
4. Analyze the knowledge about membrane transport and translocation of water and solutes.
5. Summarize the process of photosynthesis in higher plants with particular emphasis on light and dark reactions, C<sub>3</sub> and C<sub>4</sub> pathways, respiration in higher plants with particular emphasis on aerobic and anaerobic respiration, ATP synthesis, and nitrogen metabolism.
6. Create a general idea of plant physiology and biochemistry

Unit	Topic	No. of Lectures (45 hrs)
1	<b>Plant-water relations:</b> Importance of water, water potential and its components; transpiration and its significance; factors affecting transpiration; root pressure and guttation. <b>Mineral nutrition:</b> Essential elements, macro and micronutrients; criteria of essentiality of elements; role of essential elements; transport of ions across cell membrane, active and passive transport, carriers, channels and Pumps	10
2	<b>Photosynthesis:</b> (photosynthetic Pigments (Chl a, b, xanthophylls, carotene); photosystem I and II, electron transport and mechanism of ATP synthesis; C <sub>3</sub> , C <sub>4</sub> and CAM pathways of carbon fixation; photorespiration). <b>Respiration</b> (glycolysis, anaerobic respiration, TCA cycle; oxidative phosphorylation, glyoxylate cycle).	15
3	<b>Nitrogen metabolism:</b> Biological nitrogen fixation; nitrate and ammonia assimilation. <b>Plant growth regulators:</b> Discovery and physiological roles of auxins, gibberellins, cytokinins, ABA, ethylene.	10
4	<b>Biochemistry:</b> General introduction to carbohydrates, lipids and proteins. Enzymes (structure and properties; mechanism of enzyme catalysis and enzyme inhibition, factors affecting enzyme action).	10

### Suggested Readings

- Taiz, L., Zeiger, E., (2010). Plant Physiology. Sinauer Associates Inc., U.S.A. 5<sup>th</sup> Edition.
- Hopkins, W.G., Huner, N.P., (2009). Introduction to Plant Physiology. John Wiley and Sons, U.S.A. 4<sup>th</sup> Edition.
- Bajracharya, D., (1999). Experiments in Plant Physiology- A Laboratory Manual. Narosa Publishing House, New Delhi.

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**Practical/Lab Course  
BOTDL602**

**Course Outcomes:**

1. Gain knowledge of the determination of the osmotic potential of plant cell sap. Effect of the permeability of the cytoplasmic membrane, water potential, osmosis, and photosynthesis.
2. Understand the effect of environmental factors on transpiration.
3. Apply the formula to calculate the stomatal index and frequency of the plant leaf.
4. Analyze the separation of chloroplast pigment and amino acids by chromatography.
5. Evaluate the rate of respiration by Respirometer
6. Develop to demonstrate suction due to transpiration

Unit	Topic	No. of Lectures (60 hrs)
1	Demonstration of process of diffusion, osmosis, and plasmolysis Demonstration of transpiration in dorsiventral leaf by four leaf and cobalt chloride method. Determination of rate of transpiration by Ganong's/Farm potometer. Demonstration of the effect of light intensity and bicarbonate concentration on O <sub>2</sub> evolution in photosynthesis by Wilmotts Bubler.	18
2	Determination of R.Q of different respiratory substrates by Ganong's respirometer; Demonstration of anaerobic respiration in germinating seeds. Demonstrate Suction due to transpiration	18
2	Test of carbohydrates, proteins, and fats.	12
4	Separation of amino acids and chloroplast pigment by paper chromatography	6
5	Calculation of stomatal index and stomatal frequency of a mesophyte and a xerophyte	6

**Suggested Readings**

- Bajracharya, D., (1999). Experiments in Plant Physiology- A Laboratory Manual. Narosa Publishing House, New Delhi.
- Swami. (2012). Practical Botany Vol III. Pragati Prakashan, Meerut

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**Semester-VII**  
**Mycology and Microbiology**  
**BOTDC701**

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

1. Recall the knowledge about the history, concept and scope of mycology and microbiology
2. Understand the general characters, structure, nutrition, reproduction and the principles on classifications of Fungi, occurrence, general characters, types, reproduction and life cycles of the major microbial groups and their role in food, clinical and industrial microbiology.
3. Apply practical skills in basic microbiological techniques. Explain and think about the symptoms and causal organisms of various fungal diseases of plants.
4. Analyze the importance of the characteristics, mode of reproduction and economic importance of Fungi and Viruses
5. Summarized the occurrence, general characters, types, reproduction and life cycles of the major fungal groups and Evaluate the classificatory approaches and advances in bacterial, viral and lichen taxonomies
6. Develop fungal associations and fungal physiology and Generalized the knowledge about the Microbiology

Unit	Topic	Total No. of lecturers/hrs (45)
1	General characteristics (Somatic structures, cell wall composition, and nutrition in fungi), Reproduction in Fungi (vegetative, asexual, and sexual), Heterothallism and Heterokaryosis, Parasexual cycle, Mycorrhiza. Recent trends in classification of fungi, phylogeny of Fungi, Importance of Fungi. A general account of the following classes of fungi with emphasis on the given genera: Mastigomycotina: <i>Allomyces</i> , <i>Monoblepharis</i> , <i>Saprolegnia</i> , <i>Pythium</i> , <i>Phytophthora</i> , <i>Sclerospora</i> . Zygomycotina: <i>Mucor</i> , <i>Pilobolus</i> , <i>Entomophthora</i>	10
2	Ascomycotina: <i>Saccharomyces</i> , <i>Aspergillus</i> , <i>Talaromyces (Penicillium)</i> , <i>Taphrina</i> , <i>Phyllactinia</i> , Basidiomycotina: <i>Puccinia</i> , <i>Ustilago</i> , <i>Uromyces</i> . Deuteromycotina: <i>Fusarium</i> , <i>Cercospora</i> , <i>Pyricularia</i> , <i>Colletotrichum</i> , <i>Trichoderma</i> , <i>Helminthosporium</i>	10
3	.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.	10
4	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, Corona virus.	10

5	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.	5
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#### Suggested readings

- Ainsworth, G.C. (1976). Introduction to the history of Mycology. Academic Press. New York.
- Alexopoulos, C.J. and Mims C.W. (1995). Introductory Mycology. John Wiley and Sons. New York. Fourth Edition.
- Bryce Kendrick. (2017). The Fifth Kingdom: An Introduction to Mycology. Hackett Publishing. 4<sup>th</sup> Edition.
- John Webster and Roland Weber. (2007). Introduction to Fungi. Cambridge University Press. 3<sup>rd</sup> Edition.
- Kavanagh, Kevin. (2018). Fungi: Biology and Applications. Wiley-Blackwell. 3<sup>rd</sup> edition.
- Mehrotra, R.S. and K.R. Aneja. (1999). An Introduction to Mycology. New Age International Publisher.
- Sati, S.C. and Belwal, M. (2012). Microbes Diversity and Biotechnology. Daya Publication.
- Webster, J. (1985). Introduction to Fungi. Cambridge University Press. New York.
- 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. Kathleen Park, Talaro and Barry Chess. (2017). Foundations in Microbiology. Mc Graw Hill New York, 10<sup>th</sup> edition.
- Kaushik, P. (1996). Introductory Microbiology. EmkayPubl, Delhi.
- Madigan, Bender, Buckley, Sattley, Stahl. (2019). Brock Biology of Microorganisms. Pearson. 15<sup>th</sup> edition.
- Marjorie, Kelly. And Cowan, Heidi Smith. (2017). Microbiology: A Systems Approach. McGraw 29ioferti York, 5<sup>th</sup> edition.
- 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.
- Pelczar, M.J., Chan, ECS and Kreig, N.R. (1993). Microbiology. McGraw Hill, New York. Fifth Edition.
- Power, C.B. and Daginawala H.F. (1996). General Microbiology. Vol 2. Himalaya Pub. House, New Delhi.
- Tortora, G. J., Funke, B.R. and Case C.L.(2021). Microbiology: An Introduction, Pearson Benjamin Cummings, U.S.A. 13<sup>th</sup> edition.
- Willey, Joanne, Sherwood, Linda., Woolverton, Christopher J.(2017). Prescott's Microbiology. McGraw Hill New York, 11<sup>th</sup> edition.

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Sanku Kanchar

**Practical/Lab Course**  
**BOTDL702**

**Course Outcomes:**

1. Recall the knowledge of different genera belong to different classes of fungi and microbes.
2. Understanding about different instruments and lab safety rules.
3. Illustrate the methods of isolation and identification
4. Analyze the agar plate technique for isolation, enumeration and identification
5. Reframe the identification and Isolation of fungi and bacteria.
6. Assemble the knowledge of media preparation

Unit	Topic	Lecture hrs (60)
1	Study of representative genera of Zygomycotina, Ascomycotina, Basidiomycotina and Deuteromycotina.	10
2	Symptomatology of at least one diseased specimen of plant pathogens belonging to various fungal sub-division i.e. Mastigomycotina, Zygomycotina, Acomycotina, Basidiomycotina and Deuteromycotina	7
3	Aseptic methods and demonstration of instruments viz., autoclave, hot air oven, incubator, Laminar-airflow.	8
4	Isolation and enumeration of microbes from natural samples (soil and water) by agar plate technique	10
5	Direct examination of root nodule bacteria under microscope and isolation of Rhizobium in root nodules	5
6	Symptomology and diseased specimens of plants caused by bacteria and viruses	5

**Suggested Readings**

- B.P. Pandey. (2019). Practical Botany-Revised ed. S. Chand Co. Ltd. Delhi
- O.P. Sharma. (2016). A text book of Practical Botany. Rastogi Publ.
- Gupta, Bajpai and Singh. (2020). Integrated Biodiversity Manual Pragati Prakashan, Meerut
- Aneja, K.R. 2016. Experiments in Microbiology, Plant Pathology, Tissue Culture and Biotechnology, New Age International Publisher.

**Semester-VIII**  
**Palynology and Pollination Biology**  
**BOTDC801**

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

1. Remember and Recall the general concepts of palynology.
2. Learn and understand the structure and development of pollen wall development.
3. Examine the morphological features of Spore-pollen.
4. Relate and identify the various aspects of Palynotaxonomy.
5. Analyze the importance of aero-palynology with reference to allergy.
6. Determine the concepts, scope and future perspectives of Melissopalynology

Unit	Topic	Total No. of lecturers/hrs (45)
1	General Introduction, microsporogenesis, microspore tetrads and polarity of spores and pollen grains. Pollen wall development and pollen chemistry, Chemical nature of sporopollenin, development of pollen wall, Urisch body, pollen wall proteins, origin and formation exineless pollen grains.	10
2	<b>Spore-pollen morphology:</b> Symmetry, shape, size, aperture patterns, NPC System for numerical expression of apertural details, exine stratification, surface structures and sculptures of sporoderm. <b>Palynotaxonomy:</b> Systematic palynology, identification key and evolutionary trends among pollen grains based on palynotaxonomical works.	10
3	<b>Aeropalynology with reference to allergy:</b> Aeroallergens, introductory idea of Immune System with special reference to IgE. Study of airspora, chemical nature of exine-borne allergens, allergic taxa of North-West Himalaya. <b>Melissopalynology:</b> Indian species of honey bees, importance of pollen grains as constituent of bee-bread, pollen-collecting mechanism of honey bees, analysis of pollen load and honey sample in understanding bee forage, objectives of melissopalynological studies, and important bee plants of North-West Himalaya.	15
4	<b>Forensic palynology:</b> Definition and significance, a few well-known case studies. <b>Pollination Biology:</b> Pollen dispersal units; pollination types, contrivances for cross- and self- pollination; pollen vectors, pollination modes and flora organization, Pollen viability and storage.	10

### Suggested Readings

1. Erdtman, G. 1952. Pollen morphology and Plant Taxonomy, Angiosperm: Almquist and Wiksell, Stockholm.
2. Bhattacharya, K. and Majumdar, M.R. 2011. A text book of Palynology. P364. New Central Book Agency.
3. Nair, P.K.K. 1966. Essentials of Palynology; Asia Publication House Lucknow.
4. Woodhouse, R.P. 1935. Pollen Grains: Hafner Publication Co.

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**Practical/Lab Course  
BOTDL802**

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

1. Examine the pollen grains from honey samples and to study the frequency of different Morpho-types.
2. Distinguish the in vivo and in vitro germination of pollen grains.
3. Apply knowledge to study allergy producing pollen Morpho-types
4. Analyze Morpho-anatomical study of stigma and style
5. Evaluate pollen viability of angiosperms
6. Solve the problem related pollen morphology

Unit	Topic	Total No. of lecturers/ hrs (60)
1	Pollen morphological studies of some Pteridophyte, gymnosperms, and angiosperms representing different morphological types using acetolysis / alkali maceration method.	20
2	Study of in vivo and in vitro germination of pollen grains.	15
3	Study of allergy producing pollen morpho-types.	5
4	Determination of pollen viability	5

**Suggested Readings**

Bhattacharya, K. and Majumdar, M.R. 2011. A text book of Palynology. p364. New Central Book Agency.  
James, B. Riding. 2021. A guide to preparation protocols in palynology. Taylor and Francis.

**Discipline-Specific Elective**  
**Semester-V**  
**Cell and Molecular Biology & Plant Biotechnology**  
**BOTDE503**

**Course outcomes:**

1. Remember the principles and details of using light and electron microscopes and the role of X-ray diffraction in studying the structures of cellular organelles and biomolecules and define various types of cell organelles and their functions. Basic tools of Plant tissue culture, Recombinant DNA Techniques.
2. Identify the role of enzymes in plant development and basic techniques of Biotechnology.
3. Explain the basic principles of microscopy and basic techniques of Recombinant DNA Technology
4. Analyze the process of cell cycle with reference to mitosis and meiosis.
5. Compare and Discuss about the SEM and TEM with reference to their applications in plant study. Basic concept of biotechnology and its application with reference to plants.
6. Construct the structures of different RNA and enzymes used in transcription

Unit	Topic	No. of Lectures (45 hrs)
1	<b>Cell Biology:</b> The cell theories, prokaryotic and eukaryotic cells, cell organelles (Mitochondria, Chloroplast, ER, golgi body, lysosomes, peroxisomes, glyoxisomes, nucleus, chromatin; DNA packaging in eukaryotes, euchromatin and heterochromatin, nucleolus and ribosome structure), cell membrane and cell wall; models of membrane structure, cell cycle (overview of cell cycle, mitosis and meiosis, molecular controls).	10
2	<b>Molecular Biology:</b> Genetic material (DNA: Miescher to Watson and Crick- historic perspective, Griffith's and Avery's transformation experiments, Hershey-Chase bacteriophage experiment, DNA structure, types of DNA, types of genetic material); DNA replication (Prokaryotes); Transcription (Prokaryotes) Types of structures of RNA (mRNA, tRNA, rRNA); Translation (Prokaryotes), Regulation of gene expression (Prokaryotes: Lac operon and Tryptophan operon).	15
3	<b>Plant tissue culture:</b> Culture types on the basis of explants and media composition, General lab setup and instrumentation, micropropagation, A brief account of protoplast culture, and somatic embryogenesis with their applications.	10
4	<b>Recombinant DNA techniques:</b> Blotting techniques: Northern, Southern, and Western Blotting, Molecular DNA markers i.e. RAPD, RFLP, SNPs, PCR, hybridoma and monoclonal antibodies, ELISA and Immunodetection.	10

### Suggested readings

- Karp, G. (2010). Cell and Molecular Biology: Concepts and Experiments. 6<sup>th</sup> Edition. John Wiley and Sons. Inc.
- De Robertis, E.D.P. and De Robertis, E.M.F. (2006). Cell and Molecular Biology. 8<sup>th</sup> edition. Lippincott Williams and Wilkins, Philadelphia.
- Cooper, G.M. and Hausman, R.E. (2009). The Cell: A Molecular Approach. 5<sup>th</sup> edition. ASM Press and Sunderland, Washington, D.C.; Sinauer Associates, MA.
- Becker, W.M., Kleinsmith, L.J., Hardin. J. and Bertoni, G.P. (2009). The World of the Cell. 7<sup>th</sup> edition.
- Bhojwani, S.S. and Razdan, M.K., (1996). Plant Tissue Culture: Theory and Practice. Elsevier Science Amsterdam. The Netherlands.
- Glick, B.R., Pasternak, J.J. (2003). Molecular Biotechnology- Principles and Applications of recombinant DNA. ASM Press, Washington.

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**Discipline-Specific Elective  
Semester-V  
Practical/Lab Course  
BOTDL504**

**Course outcomes:**

1. Examine various cell organelles through slides and photographs.
2. Gain an understanding of temporary mount and slides of mitosis and meiosis.
3. Practice the section cuttings.
4. Illustrate the structure of nuclear pore complex by photograph.
5. Measure the cell size (either length or breadth/diameter) by micrometry.
6. Test the process of plasmolysis and deplasmolysis on Rhoeco leaf and Assemble the knowledge of Anther culture, somatic embryogenesis, endosperm and embryo culture; micropropagation

Unit	Topic	No. of Lectures (60 hrs)
1	Structure of prokaryotic cells (bacteria), viruses, and eukaryotic cells with the help of light and electron micrographs. Study of the photomicrographs of cell organelles, the structure of plant cell through temporary mounts. Study of mitosis and meiosis (temporary mounts and permanent slides). Demonstration of the effect of temperature, organic solvent on the semi-permeable membrane. Study of plasmolysis, deplasmolysis,	20
2	Instruments and equipment used in molecular biology The cell size measurements (either length or breadth/diameter) by micrometry. Study the structure of nuclear pore complex by photograph (from Gerald Karp) Study of special chromosomes (polytene and lampbrush) either by slides or photographs. Study DNA packaging by micrographs. Preparation of the karyotype and ideogram from given photograph of somatic metaphase chromosome.	20
3	Familiarization with basic equipments in tissue culture. Study through photographs: Anther culture, somatic embryogenesis, endosperm and embryo culture; micropropagation. .Study of molecular techniques: PCR, Blotting techniques, AGE and PAGE	20

**Suggested readings**

- Karp, G. (2010). Cell and Molecular Biology: Concepts and Experiments. 6<sup>th</sup> Edition. John Wiley and Sons. Inc.
- Bhojwani, S.S. and Razdan, M.K., (1996). Plant Tissue Culture: Theory and Practice. Elsevier Science Amsterdam. The Netherlands.
- V.K. Jain. (2016). A textbook of Biotechnology. S.Chand Publ., New Delhi

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**SEMESTER-VI**  
**Ecology and Biostatistics**  
**BOTDE603**

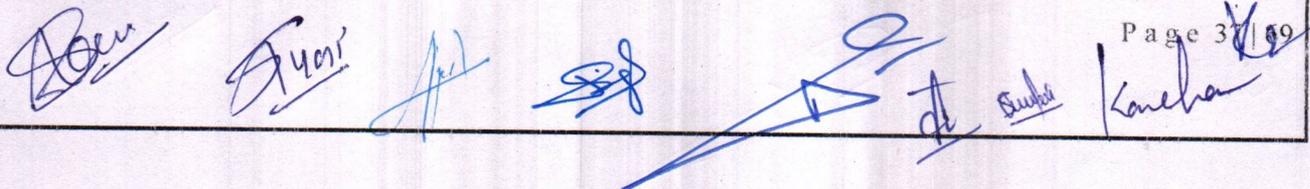
**Course outcome**

1. Remember to define various components of environment and ecosystem and biostatistical terminology.
2. Understand methods for studying vegetation, community patterns and processes, ecosystem function, and principles of phytogeography.
3. Applying: different statistics tools to solve problems in biology.
4. Analyze complex interrelationships between organisms and the environment.
5. Evaluate strategies for sustainable natural resource management and biodiversity conservation.
6. Create to develop, write or construct Biogeochemical cycling in nature

Unit	Topic	No. of Lectures (45 hrs)
1	<b>Ecological factors:</b> <b>Soil</b> (Origin, formation, composition, soil profile) <b>Plant adaptation</b> in relation to water (Hydrophytes and xerophytes), light (Sciophytes and heliophytes), and temperature; <b>Pollution:</b> Water, Soil and Radioactive.	10
2	<b>Ecosystem:</b> Types, structure, energy flow, trophic organization, food chains and food webs, ecological pyramids. <b>Biogeochemical cycles:</b> Cycling of carbon, nitrogen, and phosphorous. <b>Population:</b> Characteristics, Growth curves, Ecotypes, and Ecads <b>Plant communities:</b> Characteristics, plant succession, Biological spectrum <b>Biodiversity conservation</b>	15
3	<b>Biostatistics:</b> Definition and scope of statistics, sampling techniques, representation of data: tabular, graphical, etc <b>Measures of central tendency:</b> Arithmetic mean, mode, median.	10
4	<b>Measures of dispersion:</b> range, mean deviation, variation, standard deviation; Chi-square test for goodness of fit Regression analysis	10

Suggested reading

- Sharma, P.D. (2010) Ecology and Environment. Rastogi Publications, Meerut, India. 8<sup>th</sup> edition.
- Shukla, R.S. and Chandel P.S. (2005). A text book of Plant Ecology. S. Chand and Company Ltd., Ram Nagar, New Delhi.
- Rastogi, V.B. (2015). Biostatistics. Medtech, 3<sup>rd</sup> Edition.
- Banerjee, P.K. (2006). Introduction to Biostatistics. S. Chand and Company Ltd., Ram Nagar, New Delhi.
- Singh, J.S. Singh S.P. and Gupta, S.R. (2014). Ecology, Environment and Resource Conservation. S. Chand and Company Pvt. Ltd., New Delhi.



**Ecology and Biostatistics**  
**BOTDL604**

**Course Outcomes:**

1. Remember the knowledge of instruments used to measure microclimatic variables.
2. Understand effect of environmental factors on transpiration.
3. Apply practical knowledge of biostatistics implemented in the biodiversity assessment and conservation.
4. Analysis of two soil samples for carbonates, chlorides, nitrates, sulphates, organic matter and base deficiency by rapid field test.
5. Evaluate morphological adaptations of hydrophytes and xerophytes and rate of respiration.
6. To test goodness of fit using chi-square.

Unit	Topic	No. of Lectures (60 hrs)
1	Observation and study of different ecosystems mentioned in the syllabus. Study of instruments used to measure microclimatic variables: Soil thermometer, maximum and minimum thermometer, rain gauge and lux meter. Determination of Ph, and analysis of soil samples for soil moisture, organic carbon, nitrogen and phosphorus. Comparison of bulk density, porosity and rate of infiltration of water in soil of three habitats. Study of ecological adaptations in hydrophytes and xerophytes. Study of biotic interactions of: stem parasite ( <i>Cuscuta</i> ), root parasite (orobanche), epiphytes, predation (insectivorous plants) through specimen or diagrams. Determination of minimum quadrat size for the study of herbaceous vegetation by species area curve method (species to be listed). Quantitative analysis of herbaceous vegetation in the college campus for frequency, density, abundance and A/F ratio. Population structure study of dominant tree species of the locality.	30
4	Analysis of statistical data: mean, median and mode by analyzing the given data of individual, discrete and continuous series, standard error and deviation Numerical based on correlation coefficient Numerical based on chi square value Representation of data by making graphs and diagrams etc. Comment upon given graphs, diagrams etc.	30

**Suggested Readings**

- Zar, J.H. (2012). Biostatistical Analysis. Pearson Publication. U.S.A. 4th edition
- Banerjee, P.K. (2016). A textbook of Biostatistics. S.Chand Publ., New Delhi.



**SEMESTER-VII**  
**Plant Resource Utilization and Conservation**  
**BOTDE703**

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

1. Remember and define the concepts of Plant resources its economic value and conservation
2. Describe economically important plants with binomial names, family and uses.
3. Explain the various uses of plants; biodiversity status, loss and management strategies
4. Analyze initiatives for biodiversity conservation.
5. Evaluate the economically important product and its utility,
6. Create Germplasm storage for the conservation of economically important crops.

Unit	Topic	Total No. of lecturers/ hrs (45)
1	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.	10
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. Lesser known plants of Uttarakhand and their economic importance Wild edible plants of Uttarakhand: 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).	15
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.	10
4	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.	10

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#### Suggested readings

- 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.
- Kochhar S.L. (2016). Economic Botany. Cambridge University Press, London.
- Pandey, B.P. (1999). Economic Botany. S. Chand, New Delhi.
- Paroda R.S. and Arora R.K. (1991). Plant genetic resources Conservation and Management. International Board for Plant Genetic Resources, (IBPGR), Rome, (Italy)
- Pullin A.S. (2002). Conservation Biology. Cambridge University, Press, London.
- 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).

**Practical/Lab Course  
BOTDL704**

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

1. Recall the knowledge of different plant resources and its utilization
2. Understand Morphology, anatomy and uses of different crop plants
3. Apply micro-chemical test for the detection of carbohydrate and proteins in crops.
4. Analyze microscopic study of whole fibers using appropriate staining procedures.
5. Evaluate Iodine Value
6. Create strategies for conservation of biodiversity

Unit	Topic	Total No. of lecturers/hrs (60)
1	The practical course of this section is divided into three units 1) Laboratory work, (2) Field survey and (3) Scientific visits i. Food crops: wheat, rice, maize, chickpea, potato, tapioca, sweet potato, sugarcane; morphology, anatomy and micro-chemical tests for stored food materials.	15
2	ii. Forage/fodder plants: Study of ten important fodder crops of the locality.	5
3	iii. Plant fibers: Textiles fibers (cotton, jute, sun hemp, cannabis, Grewia, etc.), Cordage fibers (coir), Stuffing fibers (silk cotton). Morphology, anatomy, microscopic study of whole fibers using appropriate staining procedures. Medicinal and aromatic plants including antibiotics.	10
4	Vegetable oils: Mustard, groundnut, soybean, coconut, sunflower and castor. Morphology, microscopic structure of oil yielding tissues, test for oil, Iodine value	10
5	Scientific visits, Field trips, compilation of field notes, the preparation of herbarium sheets and submission of herbarium and museum specimens, potted specimens of taxonomic interest and submission of the excursion report.	5

**Suggested Readings**

Bijan Bihari Dutta. (2015). A Handbook of Plant Resource Utilization and Conservation. Publ. by Authors press

Singh, Pande and Jain (2008). Economic Botany. Rastogi Publication

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**Research Methodology**  
**BOTDE705**

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

1. Remember laboratory practices and acquire the knowledge about the common toxic chemicals and safety measures during their handling.
2. Understand ability to review literature and documenting, and presenting data in a format suitable for publication in peer-reviewed journals
3. Apply Knowledge of major instruments required to conduct research work
4. Analyze technical aspects and essential requirements of tissue culture technology
5. Evaluation of data, data collection and presentations.
6. Create statistical tools for interpretation of data, and testing of hypothesis.

Unit	Topic	Total No. of lecturers/hrs (45)
1	Basic concepts of research Research-definition and types of research (Descriptive vs. analytical; applied vs. fundamental; quantitative vs. qualitative; conceptual vs. empirical). Research methods vs. methodology. Literature-review and its consolidation; Library research; field research; laboratory research.	12
2	General laboratory practices Common calculations in botany laboratories. Understanding the details on the label of reagent bottles. Molarity and normality of common acids and bases. Preparation of solutions. Dilutions. Percentage solutions. Molar, Molal and normal solutions. Technique of handling micropipettes; Knowledge about common toxic chemicals and safety measures in their handling	13
3	Data collection and documentation of observations Maintaining a laboratory record; Tabulation and generation of graphs. Imaging of tissue specimens and application of scale bars. The art of field photography. Overview of Biological Problems History; Key biology research areas, Model organisms in biology (A Brief overview): Genetics, Physiology, Biochemistry, Molecular Biology, Cell Biology, Genomics, Proteomics-Transcriptional regulatory network.	12
4	The art of scientific writing and its presentation Numbers, units, abbreviations and nomenclature used in scientific writing. Writing references. Power point presentation. Poster presentation. Scientific writing and ethics, Introduction to copyright-academic misconduct/plagiarism.	8

**Suggested Readings:**

1. Stapleton, P., Yondeowei, A., Mukanyange, J., Houten, H. (1995). Scientific writing for agricultural research scientists – a training reference manual. West Africa Rice Development Association, HongKong.
2. C.R. Kothari. (2004). Research Methodology-Methods and Techniques. New Age International (P) Ltd., New Delhi.
3. N. Arumugam. (2015). Research Methodology for Life Science, Saras Publication, 748p



**Practical/Lab Course  
BOTDL706**

**Course Outcome:**

1. Gain knowledge of practical based on chemical calculation
2. Gain understanding of plant micro-technique
3. Apply to make images through microphotography
4. Explain technical report writing
5. Justify the research through presentation
6. Validate ethical guidelines

Unit	Topic	Total No. of lecturers/hrs (60)
1	Plant micro-technique experiments	15
2	The art of imaging of samples through microphotography and field photography.	15
3	Poster presentation on defined topics.	15
4	Technical writing on topics assigned	15

**Suggested Readings**

1. Dawson, C. (2002). Practical research methods. UBS Publishers, New Delhi.
2. Ruzin, S.E. (1999). Plant microtechnique and microscopy. Oxford University Press, New York, U.S.A.

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**Taxonomy and Diversity of Flowering Plants**  
**BOTDE707**

**Course Outcome:**

After the completion of the course the students will be able to

1. Remembering the depth knowledge salient features of angiosperms, concept of origin and evolution of angiosperms.
2. Understand about the diversity, description, identification, nomenclature and classification of plants
3. Familiarized with the salient features of ICBN/ICN species concept, taxonomic hierarchy, and delimitation of taxa and attribution of rank.
4. Analyze the types of inflorescence and their origin. Analyze the plants and describe them taxonomically
5. Summarized the concepts of phytogeography, endemism, plant migration, invasions and introduction. Skills in Plant inventory and exploration, identification and its conservation.
6. Develop the characteristic features and economic importance of some important families.

Unit	Topic	Total No. of lecturers/hrs (45)
1	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. The species concept: Taxonomic Hierarchy, species, genus, family and other categories. Principles used in assessing relationships, delimitation of taxa and attribution of rank.	10
2	Origin of intra-population 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.	10
3	Taxonomic tools, herbarium, flora, histological, cytological, phytochemical, serological, biochemical, and molecular techniques. Concepts of phytogeography, endemism, plant migration, invasions and introduction.	10
4	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.	15

**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 Linnean Society 181: 1-20.
- 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. (2010). Taxonomy of Angiosperms. I.K. International Pvt. Ltd.
- Saxena N.B. and Saxena S. (2012). Plant Taxonomy Pragati Prakashan.

**Practical/Lab Course**  
**BOTDL708**

**Course Outcome:**

1. Recall the knowledge of different genera belong to different classes of Angiosperms
2. Understand the basic terminology of taxonomy
3. Apply the methods of identification with the help of keys and flora
4. Execute and analyze the herbarium preparation and to enhance their knowledge regarding conservation of plants through field trips
5. Justify the knowledge of locally available flora
6. Report preparation of Field trips, compilation of field notes, the preparation of museum specimens and/or live potted specimens of taxonomic interest and submission of the excursion report

Unit	Topic	Total No. of lecturers/hrs (60)
1	Identification and description of locally available plants belonging to families included in the syllabus from fresh specimens, herbarium or preserved materials. After identification up to family level any suitable regional Flora may be provided for generic identification if required.	15
2	Description of a species based on various specimens to study intraspecific variation.	15
3	Studies to find out the location of key characters and preparation of keys at generic level.	15
4	Field trips, compilation of field notes, the preparation of herbarium sheets and submission of herbarium and museum specimens and/or live potted specimens of taxonomic interest and submission of the excursion report.	15

**Suggested Readings**

1. Rajan Sundara, S. (2021). Practical Manual of Angiosperm Taxonomy. Anmol Publication Pvt. Ltd.
2. Sinha, R.K. (2020). Practical Taxonomy of Angiosperm. IK International Pvt. Ltd. P.454

**Discipline Specific Elective  
SEMESTER-VIII  
Plant Health Management  
BOTDE803**

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

1. Remember the terms associated with plant health management and basic procedure of diagnosis and significance of plant diseases.
2. Understand the concepts of seed pathology and learn defense mechanism in plants
3. Explain and illustrate the important of plant diseases with reference to Nursery, cash crops.
4. Explain and identify the important diseases of plantation.
5. Summarized and address the various types of mycorrhizal associations and their role in forestry.
6. Generalize and write the diseases of cereals, millets, vegetables and fruit trees.

Unit	Topic	Total No. of lecturers/hrs (45)
1	Basic procedure in diagnosis of plant diseases: Significance of plant diseases. Seed Pathology: Seed borne fungi. Disease transmitted through seeds. Biodeterioration of seed in storage. Control of seed borne fungi.	10
2	Nursery disease: Important disease of nursery plants. Plantation disease: Plantation disease of Chir pine, <i>Eucalyptus</i> , Sal, Teak, Shisam, <i>Populus</i> , <i>Acacia</i> (Catechu).	10
3	Important disease of cash crops: Sugarcane, Potato and Ginger. How plants defend themselves against pathogen. Control of crop and forest disease. Treatment of wounds. Introduction and various forms of Mycorrhiza. Role of Mycorrhiza in Forestry	15
4	Diseases of cereals, millets, vegetables and fruit trees	10

**Suggested Readings**

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

**Practical/Lab Course  
BOTDL804**

**Course Outcome:**

1. Remember the fundamentals of Plant Diseases.
2. Understand Symptoms, causes, etiology of the pathogen.
3. Apply seed soak method for the detection of seed borne pathogen
4. Analyze and Isolate some important plant pathogen.
5. Evaluate and Isolation of Fungi/bacteria by the Pour- plate method, Spread-pate and Streak Plate method
6. Test the presence of pathogen in diseased plant

Unit	Topic	Lecture Hours (60)
1	Study of seed borne pathogen. Description of pathogen, symptoms and section cutting	15
2	Isolation of some important pathogens. Procedure of equipment uses.	15
3	To establish a plant disease clinic in the department for advise to local people.	8
4	Diseases of crops, plantation crops, fruit trees through specimens	7

**Suggested Readings**

Husain Hadi Khan et al. 2019. Practical Lab manual for microbiology and plant pathology, Akinik Publication, Delhi.  
Aneja, K.R. 2016. Experiments in Microbiology, Plant Pathology, Tissue Culture and Biotechnology, New Age International Publisher.

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**Genetics, Plant Breeding and IPR**  
**BOTDE805**

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

1. Remember the concept of Mendelian and non-mendelian inheritance, quantitative genetics, molecular markers and linkage mapping, prokaryotic and eukaryotic genome-structure, gene function and regulation, epigenetics, cytogenetics.
2. Understand to integrate molecular methods with conventional improvement strategies to accelerate plant breeding.
3. Apply to gain knowledge on commercially important plants, their breeding systems and strategies employed for crop improvement.
4. Analyze the basic concepts of intellectual property rights.
5. Evaluate the procedure for obtaining the intellectual property rights.
6. Generalized the concept of Genetics, Plant Breeding and IPR

Unit	Topic	Total No. of lecturers/hrs (45)
1	Principles of inheritance: Mendelian laws along with molecular explanations, Exceptions to Mendelian laws, lethal alleles and Gene Interactions. Structural and numerical alterations in chromosomes: Origin, occurrence, production and meiosis of haploids, aneuploids and euploids, induction and characterization of trisomics and monosomics.	8
2	Genetics of prokaryotes and eukaryotic organelles: genetic recombination of phage; genetic transportation, conjugation and transduction in bacteria, cytoplasmic male sterility. Gene structure and expression: Genetic fine structure, cis-trans test; fine structure analysis of eukaryotes, introns and their significance, regulation of gene expression in prokaryotes and eukaryotes. DNA damage and repair mechanism, defects in DNA repair; Initiation of cancer at cellular level, proto oncogenes and oncogenes.	10
3	Genetic recombination and genetic mapping: Recombination; independent assortment and crossing over, linkage groups, genetic markers, construction of molecular maps. Mutations: Spontaneous and induced mutations; physical and chemical mutation, molecular basis of gene mutation; mutations induced by transposons.	7

4	The role of plant breeding – historical aspects and genetic basis: mode of reproduction in relation to breeding methods, breeding techniques; method of plant breeding in relation to self-pollinated and cross pollinated plants. Hybridization: Interspecific and inter generic; pure line; back cross hybridization; self- incompatibility system. Breeding for resistance to diseases, physiological races. Plant breeding work done in India with special reference to potato, paddy, wheat and sugarcane. Maintenance of collection, registration of varieties, seed production, testing, certification and distribution.	10
5	<p><b>Introduction to intellectual property right (IPR)</b>  Concept and kinds. Economic importance. IPR in India and world: Genesis and scope, some important examples. IPR, WTO TRIPS and WIPO. <b>Patents</b> Objectives, Rights, Patent Act 1970 and its amendments. Procedure of obtaining patents, Working of patents, Infringement.</p> <p><b>Copyrights:</b> Introduction, Works protected under copyright law, Rights, Transfer of Copyright, Infringement.</p> <p><b>Trademarks:</b> Objectives, Types, Rights, Protection of goodwill, Infringement, Passing off, Defenses, Domain name</p>	10

#### Suggested Readings

1. Atherly, A.G., Girton, J.R. and McDonald, J.F. 1999. The Science of Genetics. Saunders College Publishing, Fort Worth, USA.
2. Burnham, C.R. 1962. Discussions in Cytogenetics. Burgess Publishing Co., Minnesota.
3. P.K Gupta. 2016. Genetics. Rastogi Publication, Meerut.
4. B.D. Singh. 2018. Genetics and Plant Breeding. Kalyani Publisher, New Delhi.
5. Sharma, J.R. 1994. Principles and Practice of Plant Breeding. Tata McGraw Hill Publ. Co. Ltd. New Delhi.
6. N.K. Acharya (2001). Textbook on intellectual property rights, Asia Law House.
7. Manjula Guru and M.B. Rao (2003). Understanding Trips: Managing Knowledge in Developing Countries, Sage Publications.
8. P. Ganguli (2001). Intellectual Property Rights: Unleashing the Knowledge Economy, Tata McGraw-Hill.
9. Miller, A.R. and Davis M.H. (2000). Intellectual Property: Patents, Trademarks and Copyright in Nutshell, West Group Publishers.

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**Practical/Lab Course**  
**BOTDL806**

**Course Outcome:**

1. Recall the knowledge of terms associated with Genetics and Plant Breeding
2. Understand the process of sex-linked inheritance
3. Apply knowledge to study floral biology of crops
4. Analyze applications of common plant breeding techniques
5. Evaluate dockage and purity percent of seed
6. Solve problems related to genetics and plant breeding.

Unit	Topic	Total No. of lecturers/hrs (60)
1	Genetical problem son Mendelian and post- Mendelian ratios, gene interactions, sex-linked inheritance, chromosomal mapping, etc	20
2	Application of common plant breeding techniques	8
3	Identification of Indian varieties of important crops. Floral biology of local food, pulse, vegetable and horticultural crops.	10
4	Collection of germplsm of different crops being grown in the area. Seed germination, dockage, purity percentage	7

**Suggested Readings**

1. Singh, B.D. 2016. Principles of Genetics and Plant Breeding. Kalyani Publisher, New, Delhi
2. Bineeta Singh, G.M. Lal. 2022. Practical Manual of Genetics and Plant Breeding. Satish Serial Publishing House, New Delhi.

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**Freshwater Algal Flora of Himalaya  
BOTDE807**

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

1. Recall the taxonomic keys for identifying different floral diversity in the Himalayan region.
2. Understand freshwater diatoms and their taxonomic terminology will be useful and will have a brief insight.
3. Examine floral diversity, which plays many important and beneficial roles in freshwater ecosystems of the Himalayan regions
4. Compare characters of Green, blue-green algae and their taxonomic terminology
5. Summarized the Fresh water algal flora of Himalayan region.
6. Generalized the concept of Fresh water algal flora of Himalaya

Unit	Topic	Total No. of lecturers/ hrs (45)
1	Characters & Keys: Green and Blue-Green Algae: Taxonomy terminology, flora in Himalaya Macrophytic vegetation. Centrale and Pennale diatoms, diatom taxonomy terminology. Centrale diatom Families and Genera Melosira, Cyclotella in Himalaya. Araphid Family & genera Fragilaria, Diatoma, Meridion, Hannae in Uttarakhand Himalaya.	10
2	Characters of raphidiod and monoraphidiod families Raphidiod: Eunotia Monoraphids, Achnanthaceae – Achnanthidium, Cocconeis	10
3	Characters of naviculoid biraphid families Naviculoid diatom flora Naviculaceae: Navicula & Cymbella sensu lato & sensu stricto, Gomphonema Other naviculoid diatom flora: Diploneis, Pinnularia, Caloneis	10
4	Characters of non-naviculoid biraphid families Bacillariaceae Nitzschia, Denticula Epithemiaceae: Epithemia Surirellaceae: Surirella Algal communities in Himalayan lotic, lentic systems, wetlands Ecological preferences of abundant forms of Himalaya (OMNIDIA)	15

**Suggested Readings**

1. Fresh water Diatoms of Central Gujarat (with a review and some others). H P Gandhi, Bishen Pal Singh, Mahendra Pal Singh, Dehradun
2. Algal flora of Andaman & Nicobar Prasad & Srivastava
3. Ganga: A water marvel, A.C. Shukla and A. Vandana, Ashish Publishing House, New Delhi
4. Bellinger, E.G., Sigeo, D.C. (2010) *Freshwater Algae (Identification and Use as Bioindicators)*. Wiley- Blackwell, pp1-243.
5. Vuuren, V.J.S., Taylor, J., Gerber, A., Van Ginkei, C. (2006). *Easy identification of the most common Fresh water Algae. A guide for the identification of microscopic algae in South African Fresh waters*, Publ. by North West University, Potchefstroom, p212.

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**Practical/Lab Course  
BOTDL808**

**Course Outcome:**

1. Recall the knowledge of different genera of algae.
2. Understand about the members belong to different classes of algae
3. Develop the Cultivation of algae of commercial importance
4. Analyze or Differentiate different groups of algae
5. Evaluate methods of identification of Himalayan flora
6. Create methods to isolate fresh water algae

Unit	Topic	Lecture Hours (60)
1	Cultivation of algae of commercial importance. Study of representative genera of different families viz., Melosira, Cyclotella, Fragilaria, Diatoma, Meridion, Achnantheidium, Cocconeis, Navicula & Cymbella, Gomphonema, Diploneis, Pinnularia, Caloneis, Nitzschia, Denticula, Green and Blue-Green Algae	30
2	Collection and Diversity of algae in lotic and lentic water streams of Himalayan region and their documentation	30

**Suggested Readings**

Bellinger, E.G., Sigeo, D.C. (2010) *Freshwater Algæ (Identification and Use as Bioindicators)*. Wiley-Blackwell, pp1-243.

Vuuren, V.J.S., Taylor, J., Gerber, A., Van Ginkei, C. (2006). *Easy identification of the most common Fresh water Algae. A guide for the identification of microscopic algae in South African Fresh waters*, Publ. by North West University, Potchefstroom, p212.

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**Generic Electives**  
**SEMESTER-I**  
**Plant Science-I (BOTGE103)**

**Course Outcome**

After the completion of the course the students will be able to:

1. Remember: Define, Recall, select and recognize about the diversity of different microbes including viruses, Algae, Fungi, bryophytes, Pteridophytes.
2. Understanding: Develop, describe, classify and discuss understanding about the classification and diversity of different microbes including viruses, Algae, Fungi, bryophytes, pteridophytes & their economic importance and the structure and reproduction of certain selected bacteria, algae, fungi, bryophytes, Pteridophytes.
3. Apply: Explain morphology, anatomy and reproduction of Bryophytes. Pteridophytes. Thallus organization, classification, vegetative structure and Life cycles of microbes, algae & fungi and bryophytes.
4. Analyzing: Explain, differentiate or classify conceptual skill about identifying microbes, and pathogens.
5. Evaluating: Summarize, distinguish or conclude knowledge about developing commercial enterprise of microbial products. Host-pathogen relationship and disease management.
6. Creating: Construct, develop, generalize, prepare and write about uses of microbes, fungi, algae, bryophytes, Pteridophytes.

Unit	Topic	Lecture (Hours)
		<b>45</b>
1	<b>Microbes:</b> General characteristics and economic importance of bacteria and viruses. <b>Algae:</b> General characteristics; range of thallus, reproduction and economic importance <b>Fungi:</b> General characteristics, reproduction, ecology and significance.	<b>20</b>
2	<b>Bryophytes:</b> General characteristics, adaptations to land habit, reproduction and economic importance of bryophytes. <b>Pteridophytes:</b> General characteristics, ecological and economic importance of Pteridophytes.	<b>25</b>

**Suggested Readings**

1. Kumar, H.D. (1999). Introductory Phycology. Affiliated East-West. Press Pvt. Ltd. Delhi. 2<sup>nd</sup> edition.
2. Sethi, I.K. and Walia, S.K. (2011). Text book of Fungi and Their Allies, MacMillan Publishers Pvt. Ltd., Delhi.
3. Alexopoulos, C.J., Mims, C.W., Blackwell, M. (1996). Introductory Mycology, John Wiley and Sons (Asia), Singapore. 4<sup>th</sup> edition.
4. Pandey, S.N and Trivedi, P.S. (2015). A text book of Botany Vol.I Vikas publishing House Pvt/ Ltd, New Delhi.
5. Vashishta, P.C., Sinha, A.K., Kumar, A. (2010). Bryophyta, S. Chand. Delhi, India..
6. Vashishta, P.C., Sinha, A.K. and Kumar, A. (2010). Pteridophyta, S Chand and Company Ltd., Ramnagar, New Delhi, India.

**SEMESTER-II**  
**Plant Science-II (BOTGE203)**

**Course Outcome**

After the completion of the course the students will be able to:

1. Remember: Define, Recall, select and recognize about the gymnosperm and Lichens & their economic importance. Anatomy and Embryology of plants
2. Understanding: Develop, describe, classify and discuss understanding about the classification and diversity of gymnosperm & their economic importance and the structure and reproduction of lichens. Basic concept of plant taxonomy, morphology, anatomy and embryology.
3. Apply: Explain morphology, anatomy and reproduction of Gymnosperms.
4. Analyzing: Explain, differentiate or classify conceptual skill about lichens. Adaptive anatomy in hydrophytes and xerophytes.
5. Evaluating: Summarize, distinguish or conclude knowledge about Morphology, anatomy and embryology.
6. Creating: Construct, develop, generalize, prepare and write about uses of gymnosperms and angiosperms in various fields.

Unit	Topic	Lecture (Hours)
1	<b>Gymnosperms:</b> General characteristics, ecological and economic importance. <b>Lichens, Introduction to plant taxonomy:</b> Identification, classification, nomenclature, functions of herbarium, important herbaria and botanical gardens of the world and India.	20
2	<b>Plant Embryology:</b> Embryo, Types of ovules and embryo sacs; endosperm; types of endosperm; dicot and monocot embryo, pollination, fertilization.  <b>Plant Anatomy:</b> Types of tissues, Root and shoot apical meristems, simple, complex and secretory tissues, structure of dicot and monocot root, stem and leaf.	25

**Suggested Readings**

1. Parihar, N.S. (1991). An Introduction to Embryophyta Vol. I Bryophyta. Central Book Depot, Allahabad.
2. Vashishta, P.C., Sinha, A.K. and Kumar, A. (2010). Gymnosperms, S Chand and Company Ltd., Ramnagar, New Delhi, India.
3. Bhatnagar, S.P. and Mojtra, A. (1996). Gymnosperms. New Age International (P) Ltd Publishers, New Delhi, India.
4. Simpson, M.G. (2006). Plant Systematics. Elsevier Academic Press, San Diego, CA, U.S.A.
5. Singh, G. (2012). Plant Systematics: Theory and Practice. Oxford and IBH Pvt. Ltd., New Delhi. 3<sup>rd</sup> edition.
6. Gangulee H.C., Kar, A.K. and Santra S.C. (2011). College Botany Vol II. 4<sup>th</sup> Edition New Central Book Agency.
7. Pandey, B.P. (2010). College Botany Vol II. S. Chand and Company Ltd., New Delhi, India.

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**SEMESTER-III**  
**Plant Science-III (BOTGE303)**

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

1. Define basic concept of physiology, biochemistry, plant biotechnology.
2. Understand the basic biochemical and physiological process in plants.
3. Explain the basic of plant tissue culture techniques used in molecular biology.
4. Correlate the concept of RDT in Plant Biotechnology.
5. Summarize the concepts of Photosynthesis.
6. Generalize the concept of Plant Physiology and Plant Biotechnology

S.No.	Topics	Lecture (Hours) 45
1	<b>Plant Physiology:</b> Photosynthesis, Respiration, Nitrogen Fixation.	15
2	<b>Biochemistry:</b> carbohydrates, proteins, lipids and secondary metabolites.	15
3	<b>Plant Biotechnology:</b> Plant tissue culture, recombinant DNA technology and Techniques used in molecular biology.	15

**Suggested Readings**

1. Taiz, L., Zeiger, E., (2010). Plant Physiology. Sinauer Associates Inc., U.S.A. 5<sup>th</sup> Edition.
2. Hopkins, W.G., Huner, N.P., (2009). Introduction to Plant Physiology. John Wiley and Sons, U.S.A. 4<sup>th</sup> Edition.
3. Bajracharya, D., (1999). Experiments in Plant Physiology- A Laboratory Manual. Narosa Publishing House, New Delhi.
4. Dubey, R.C. 2018. A textbook of Biotechnology. S. Chand Publ., New Delhi.

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**SEMESTER-IV**  
**Plant Science-IV (BOTGE403)**

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

1. Define basic concept of environment and ecology, breeding, and biostatistics.
2. Understand the importance, benefits and services of biodiversity
3. Explain and apply process of conservation of biodiversity.
4. Correlate the concept of biodiversity and its conservation and global warming.
5. Summarize the concepts of Mendelian genetics, plant breeding methods, statistical methods
6. Generalize the concept of plant sciences

S.No.	Topics	Lecture (Hours)
1	<b>Biodiversity and Conservation:</b> Species, population, species interaction, ecosystem, ecological succession, environment pollution, biodiversity, In situ and ex situ conservation, International Union for Conservation of Nature (IUCN), and Climate change and its consequence.	25
2	<b>Plant Breeding and Biostatistics:</b> Mendelian principles, plant breeding methods, and applications. Representation of Data: Tabular, Graphical; Measures of central tendency: Arithmetic mean, mode, median; Measures of dispersion: Range, mean deviation, variation, standard deviation	20

**Suggested Readings**

- Krishnamurthy, K.V. (2004). An Advanced Text Book of Biodiversity – Principles and Practices. Oxford and IBH Publications Co. Pvt. Ltd. New Delhi
- B.D. Singh. 2018. Genetics and Plant Breeding. Kalyani Publisher, New Delhi.
- Sharma, J.R. 1994. Principles and Practice of Plant Breeding. Tata McGraw Hill Publ. Co. Ltd. New Delhi.
- P.K. Banerjee. 2020. An Introduction to Biostatistics. S. Chand. Publ. Pvt. Ltd.

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**SEMESTER-V**  
**Medicinal Plant Diversity of Uttarakhand (BOTGE505)**

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

7. Define various types of medicines with their functions.
8. Understand the diversity and distribution of medicinal plants in Uttarakhand
9. Apply the techniques/methods for the sustainable utilization of the medicinal plants.
10. Analyze the economic importance of medicinal plants.
11. Summarize the botanical name, family and plant parts used for human welfare.
12. Create green house for nursery preparation of medicinal plants

Unit	Topic	Total No. of lecturers/ hrs (45)
1	Retrospect and prospects of medicinal plants	5
2	Brief history, properties, action and uses of some important medicinal plants Diversity, distribution and indigenous uses of threatened medicinal plants	15
3	Policies for threatened medicinal plant conservation and management marketing of medicinal plants	15
4	Economics and exploitation of resources and people conflict	10

Suggested readings

- 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.
- 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.

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**SEMESTER-VI**  
**Global Climate Change (BOTGE605)**

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

1. Remember and Recall the concept of climate change.
2. Understand the global climate changes and global warming.
3. Explain measures being taken for the mitigation of climate changes.
4. Analyze impacts of climate change on ecosystem, forest, sea level, human health.
5. Summarize carbon foot print and carbon sequestration.
6. Generalize the concept of global climate change.

Unit	Topic	Total No. of lecturers/ hrs (45)
1	General concept of Global climate change; Greenhouse effect; Greenhouse gasses; Carbon foot print, Carbon sequestration.	15
2	Impact of global warming and climate change, weather extremes, ecosystem disruption, human health, sea level rise and impact on forests	10
3	International initiative for mitigating global changes; Inter governmental panel on climate change (IPCC); United Nation Frame work convention on Climate change	10
4	Kyoto protocol; Montreal protocol; Paris Pact; India's initiatives for mitigating climate change.	10

Suggested readings

- Singh, J.S. Singh S.P. and Gupta, S.R. (2014). Ecology, Environment and Resource Conservation. S. Chand and Compony Pvt. Ltd., New Delhi.
- Singh, S., Singh, P., Rangabhashiyam, S. and Srivastava, K. K. (2021). Global Climate Change, Elsevier.
- Mathez, E. A. and Smerdon, J. (2009). Climate Change- The Science of Global Warming and Our Energy Future, Columbia University Press.

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**ABILITY ENHANCEMENT COURSES**  
**SEMESTER-I**  
**Environment Science-I**  
**AEC-104**

**Course Outcome**

1. Discover knowledge in ecological perspective and value of environment.
2. Understand the significance of various natural resources and its management
3. Demonstrate a comprehensive understanding of the world's biodiversity and the importance of its conservation.
4. Categorize different types of pollutions and their control measures. Discover effective methods of waste Management
5. Evaluate global environmental problems and come out with best possible solutions.
6. Create environmental laws and sustainable development

Unit	Topic	Lecture Hours (45)
1	Environment: Definition, scope and importance of environment, need for public awareness; Ecosystem: Definition, scope and importance of ecosystem, classification, structure and function of an ecosystem, food chains, food web and ecological pyramids, flow of energy	10
2	Natural resources: Classification of resources, living and nonliving resources; Water resources: Use and over utilization of surface and ground water, floods and droughts, dams, benefits and problems	10
3	Biodiversity and biotic resources: Introduction, definition, genetic, species and ecosystem diversity; Value of biodiversity: Consumptive use, productive use, social, ethical, aesthetic and optional values; India as a mega diversity nation; Endangered and Endemic species, Hot spots of biodiversity	10
4	Environmental pollution: Definition, causes and effects of air pollution, water pollution, soil pollution, noise pollution	8
5	Environmental legislations: Environmental protection act, air act1981, water act, forest act.	7

**Suggested Readings**

1. Benny Joseph, "Environmental Studies", Tata Mc Graw Hill Publishing Co. Ltd, New Delhi, 1st Edition, 2006.
2. Erach Bharucha, "Textbook of Environmental Studies for Under Graduate Courses", Orient Black Swan, 2<sup>nd</sup> Edition, 2013.
3. Dr. P. D Sharma, "Ecology and Environment", Rastogi Publications, New Delhi, 12<sup>th</sup> Edition, 201

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**SEMESTER-II**  
**Environment Science-II**  
**AEC-204**

**Course Outcome**

1. Discover knowledge in ecological perspective and value of environment.
2. Understand the significance of various natural resources and its management
3. Demonstrate a comprehensive understanding of the world's biodiversity and the importance of its conservation.
4. Categorize different types of pollutions and their control measures. Discover effective methods of waste Management
5. Evaluate global environmental problems and come out with best possible solutions.
6. Create environmental laws and sustainable development

Unit	Topic	Lecture Hours (45)
1	Environment: Biogeochemical cycles Hydrological cycle, Phosphorous cycle, Nitrogen cycle	4
2	Natural resources: Mineral resources: Use and exploitation; Land resources; Energy resources: Growing energy needs, renewable and non-renewable energy sources, use of alternate energy source, case studies	8
3	Biodiversity and biotic resources: Threats to biodiversity: Habitat loss, poaching of wildlife, human-wildlife conflicts; Conservation of biodiversity: In situ and ex situ conservation; National biodiversity act.	8
4	Environmental pollution: Solid waste: Municipal solid waste management, composition and characteristics of e-waste and its management; Pollution control technologies: Waste water treatment methods, primary, secondary and tertiary; Concepts of bioremediation; Global environmental problems and global efforts: Global Warming, Climate change, Sea level rise, ozone depletion, ozone depleting substances, deforestation and desertification; International conventions / protocols: Earth summit, Kyoto protocol and Montreal protocol	15
5	Environmental legislations: Municipal solid waste management and handling rules, biomedical waste management and handling rules 2016, hazardous waste management and handling rules, Environmental impact assessment(EIA); Towards sustainable future: Concept of sustainable development, population and its explosion, crazy consumerism, environmental education, urban sprawl, concept of green building	10

**Suggested Readings**

Benny Joseph, "Environmental Studies", Tata Mc Graw Hill Publishing Co. Ltd, New Delhi, 1 st Edition, 2006.

Erach Bharucha, "Textbook of Environmental Studies for Under Graduate Courses", Orient Black Swan, 2<sup>nd</sup> Edition, 2013.

Dr. P. D Sharma, "Ecology and Environment", Rastogi Publications, New Delhi, 12<sup>th</sup> Edition, 201

**SEMESTER-III**  
**English Communication-I**  
**AEC304**

**Course Outcomes**

1. Remember the different techniques of word formation; and demonstrate knowledge of synonyms, antonyms and skills of sensible writing.
2. Understand and remember the principle, mechanism of Communication skills, essential techniques and features of effective writing and make use of them in written communication.
3. Applying, understanding and remembering the detailed processes of essential techniques and features of effective writing and make use of them in written communication. Knowledge of synonyms, antonyms and skills of sensible writing.
4. Analyzing, applying, remembering, understanding the detailed study related common errors in English and solve exercises based on them; apply acquired knowledge and skills of oral and written communication in personal and professional life.
5. Evaluating, analyzing, applying, remembering, and understanding the use of English grammar.
6. Constructing (Creating), Evaluating, Analyzing, demonstrating, remembering, and understanding the Take part in individual and group communication activities; and determine and invent new forms and methods of communication to as per the situation.

Unit	Topic	Lecture Hours (45)
1	Theory of Communication, Types and Modes of Communication: Introduction, Definitions and Function of Communication, Needs for Effective Communication	15
2	Listening Skills: Types of Listening, Developing Effective Listening Skills, Academic Listening (Lectures)	10
3	Reading Skills: Skimming, Scanning, Summary, Paraphrasing, Comprehension.	10
4	Introductory English Grammar: Parts of Speech, Tenses, Punctuation, Common Errors in English.	10

**Suggested Readings**

1. Fluency in English- Part II, Oxford University Press, 2006.
2. Business English, Pearson, 2008.
3. Language, Literature and Creativity, Orient Blackswan, 2013.
4. Language through Literature (Forthcoming) ed. Dr. Gauri Mishra, Dr. RanjhanaKaul, Dr. Brati Biswas.

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**SEMESTER-IV**  
**English Communication-II**  
**AEC304**

**Course Outcomes**

7. Remember the different techniques of word formation; and demonstrate knowledge of synonyms, antonyms and skills of sensible writing.
8. Understand and remember the principle, mechanism of Communication skills, essential techniques and features of effective writing and make use of them in written communication.
9. Applying, understanding and remembering the detailed processes of essential techniques and features of effective writing and make use of them in written communication. Knowledge of synonyms, antonyms and skills of sensible writing.
10. Analyzing, applying, remembering, understanding the detailed study related common errors in English and solve exercises based on them; apply acquired knowledge and skills of oral and written communication in personal and professional life.
11. Evaluating, analyzing, applying, remembering, and understanding the use of English grammar.
12. Constructing (Creating), Evaluating, Analyzing, demonstrating, remembering, and understanding the Take part in individual and group communication activities; and determine and invent new forms and methods of communication to as per the situation.

Unit	Topic	Lecture Hours (45)
1	Process of Communication, Barrier to Communication, Kinds of Communication; Intrapersonal, Personal, Group and Mass, Verbal and Non-verbal Communication	15
2	Listening and Speaking Skills: Listening to Talks and Presentation, Monologue, Dialogue, Group Discussion, Miscommunication, Interview, Public Speech, Pronunciation, Accent and Intonation and Rhythm.	10
3	Writing Skills; Social and Official Correspondence: Enquiries, Complaints and Replies, Letters to the Editor, Social Appeals in the Form of Letter/ Pamphlets, Standard Business Letter, Email Drafting and Etiquettes, Preparing Agenda and Writing Minutes for Meetings.	10
4	Career Skills: Job Application, Cover Letter, Bio-data, CV and Resume and Effective Profiling, Mock Interviews, Group Discussions.	10

**Suggested Readings**

1. Fluency in English- Part II, Oxford University Press, 2006.
2. Business English, Pearson, 2008.
3. Language, Literature and Creativity, Orient Blackswan, 2013.
4. Language through Literature (Forthcoming) ed. Dr. Gauri Mishra, Dr. RanjhanaKaul, Dr. Brati Biswas.

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**SKILL ENHANCEMENT COURSES**  
**SEMESTER-I**  
**Nursery and Gardening**  
**BOTSC105**

**Course Outcomes:**

1. Describe the objectives and scope of Nursery, Gardening and cultivation of various vegetables.
2. Explain about the structure and types of seed, seed dormancy, Seed production technology, seed testing and certification etc.
3. Illustrate the methods of Nursery, Gardening and vegetative propagation.
4. Analyze the definition, objectives and scope of different types of Nursery & gardening
5. Summarized the knowledge sowing and raising of seeds and seedlings, transplanting and cultivation of seedlings and marketing procedures of vegetables.
6. Design the idea of Nursery and Gardening.

Unit	Topic	No. of lecturers/ hrs (45)
1	Nursery: definition, objectives and scope and building up of infrastructure for nursery, planning and seasonal activities – Planting – direct seeding and transplants. Seed: Structure and types – Seed dormancy; causes and methods of breaking dormancy-Seed storage: Seed banks, factors affecting seed viability, genetic erosion – Seed production technology – seed testing and certification	8
2	Vegetative propagation: air-layering, cutting, selection of cutting, collecting season, treatment of cutting, rooting medium and planting of cuttings – Hardening of plants – green house – mist chamber, shed root, shade house and glass house	6
3	Gardening: definition, objectives and scope – different types of gardening- landscape and home gardening – parks and its components – plant materials and design-computer applications in landscaping – Gardening operations: soil laying, manuring, watering, management of pests and diseases and harvesting.	8
4	Sowing/raising of seeds and seedlings – Transplanting of seedlings – Study of cultivation of different vegetables: cabbage, brinjal, lady's finger, onion, garlic, tomatoes, and carrots – Storage and marketing procedures. National and state institutes related to the activity.	8

**Suggested readings**

- Bose T.K. and Mukherjee, D. (1972). Gardening in India, Oxford and IBH Publishing Co., New Delhi. Sandhu, M.K. (1989). Plant Propagation, Wile Eastern Ltd., Bangalore, Madras.  
 Kumar, N. (1997). Introduction to Horticulture, Rajalakshmi Publications, Nagercoil.  
 Agrawal, P.K. (1993). Hand Book of Seed Technology, Dept. of Agriculture and Cooperation, National Seed Corporation Ltd., New Delhi.  
 Jules J. (1979). Horticultural Science. (3<sup>rd</sup> Ed.), W.H. Freeman and Co., San Francisco, USA.

**SEMESTER-II**  
**Conservation and Management of Biodiversity**  
**BOTSC205**

**Course Outcome:**

1. Remember to define or select the role of diversity of plants and microbes and their uses.
2. Understand causes of loss of biodiversity and its management
3. Explain and apply process of conservation of biodiversity.
4. Analyze or explain the functions of government acts and bodies for the conservation
5. Evaluate or summarize role of plants in relation to Human Welfare and commercial importance: forestry and forest products, avenue trees, ornamental plants, alcoholic beverages, Fruits and nuts.
6. Develop or write the various approaches of conservation of biodiversity

Unit	Topic	No. of lecturers/ hrs (45)
1	Plant diversity and its scope- Genetic diversity, Species diversity, Plant diversity at the ecosystem level, Agrobiodiversity and cultivated plant taxa, wild taxa. Values and uses of Biodiversity: Ethical and aesthetic values, Precautionary principle, Methodologies for valuation, Uses of plants, Uses of microbes.	10
2	Loss of Biodiversity: Loss of genetic diversity, Loss of species diversity, Loss of ecosystem diversity, Loss of agrobiodiversity, Projected scenario for biodiversity loss, Management of Plant Biodiversity: Organizations associated with biodiversity management Methodology for execution-IUCN, UNEP, UNESCO, WWF, NBPGR; Biodiversity legislation and conservations.	15
3	Conservation of Biodiversity: Principles and strategies of conservation; In situ and ex situ conservation, Social approaches to conservation, Biodiversity awareness programmes..	10
4	Role of plants in relation to Human Welfare; Cereals- Wheat, Rice, Maize; Pulses- A general account; Fruits- A general account with special reference to Uttarakhand Himalaya; Alcoholic beverages. Importance of forestry its utilization and commercial aspects, Wood: Timber yielding plants of Uttarakhand Ornamental plants of India.	10

**Suggested Readings**

- Krishnamurthy, K.V. (2004). An Advanced Text Book of Biodiversity – Principles and Practices. Oxford and IBH Publications Co. Pvt. Ltd. New Delhi
- V.S. Ramachandran. (2013). Plant Diversity and Conservation, Raj Publication

**SEMESTER-III**  
**Biofertilizers**  
**BOTSC305**

**Course Outcomes:**

1. Remember the knowledge of classification, characteristics and culture maintenance of Rhizobium and Azotobacter, green manuring, organic fertilizers
2. Understanding about the green manuring, organic fertilizers, , characteristics and culture maintenance of Rhizobium and Azotobacter, Mycorrhizal association
3. Applying the knowledge about the role of Mycorrhizal associations in influencing the growth and yield of crop plants, isolation, identification, mass multiplication of Biofertilizers.
4. Analyze the General account about the microbes used as Biofertilizer
5. Summarized the recycling of biodegradable waste materials, methods of making biocompost and vermicomposts.
6. Create the idea of making Biofertilizers.

Unit	Topic	No. of lecturers/ hrs (45)
1	General account about the microbes used as biofertilizer – Rhizobium – isolation, identification, mass multiplication, carrier based inoculants, Actinorrhizal symbiosis.	10
2	Azospirillum: isolation and mass multiplication – carrier based inoculant, associative effect of different microorganisms. Azotobacter: classification, characteristics – crop response to Azotobacter inoculum, maintenance and mass multiplication.	10
3	Cyanobacteria (blue green algae), Azolla and Anabaena azolla association, nitrogen fixation, factors affecting growth, blue green algae and Azolla in rice cultivation	5
4	Mycorrhizal association, types of mycorrhizal association, taxonomy, occurrence and distribution, phosphorus nutrition, growth and yield – colonization of VAM – isolation and inoculum production of VAM, and its influence on growth and yield of crop plants.	10
5	Organic farming – Green manuring and organic fertilizers, Recycling of biodegradable municipal, agricultural and Industrial wastes – biocompost making methods, types and method of vermicomposting – field Application	10

**Suggested Readings**

Vayas,S.C, Vayas, S. and Modi, H.A. 1998 Bio-fertilizers and organic Farming AktaPrakashan,Nadiad  
Acharya, Sen and Rai. (2019). Biofertilizers and Biopesticides. Techno World Press

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**SEMESTER-IV**  
**Ethnobotany**  
**BOTSC405**

**Course Outcome:**

1. Knowledge about history, concept, scope and relevance of herbal drugs in Indian system of medicine
2. Understand the techniques for drug evaluation (Chemical, Physical and Biological), Phytochemical investigations, standardization and quality control of herbal drugs
3. Apply the technique of medicinal gardening - Cultivation practices, marketing and utilization of selected medicinal plants
4. Analyze the macroscopic and microscopic characters, chemical constituents, adulterants, therapeutical and pharmaceutical uses of medicinal plants
5. Summarize the legal aspects of ethnobotanical studies
6. Collaborate ethnobotany to ethnic group.

Unit	Topic	No. of lecturers/ hrs (45)
1	Ethnobotany Introduction, concept, scope and objectives; Ethnobotany as an interdisciplinary science. The relevance of ethnobotany in the present context; Major and minor ethnic groups or Tribals of India, and their life styles. Plants used by the tribals: a) Food plants b) intoxicants and beverages c) Resins and oils and miscellaneous uses.	10
2	Methodology of Ethnobotanical studies a) Field work b) Herbarium c) Ancient Literature d) Archaeological findings e) temples and sacred places.	7
3	Role of ethnobotany in modern Medicine Medico-ethnobotanical sources in India; Significance of the following plants in ethno botanical practices (along with their habitat and morphology) a) Azadiracta indica b) Ocimum sanctum c) Vitex negundo. d) Gloriosa superbae) Tribulus terrestris f) Pongamia pinnatag) Cassia auriculata h) Indigofera tinctoria. Role of ethnobotany in modern medicine with special example Rauwolfia sepentina, Trichopus zeylanicus, Artemisia, Withania.	12
4	Role of ethnic groups in conservation of plant genetic resources. Endangered taxa and forest management (participatory forest management)	6
5	Ethnobotany and legal aspects Ethnobotany as a tool to protect interests of ethnic groups. Sharing of wealth concept with few examples from India. Biopiracy, Intellectual Property Rights and Traditional Knowledge.	10

**Suggested Readings**

S.K. Jain (ed.) Glimpses of Indian. Ethnobotany, Oxford and I B H, New Delhi –1981.  
S.K. Jain, 1990. Contributions of Indian ethnobotny. Scientific publishers, Jodhpur  
Rajiv K. Sinha – Ethnobotany The Renaissance of Traditional Herbal Medicine – INA –SHREE Publishers, Jaipur-1996.

**SEMESTER-V**  
**Mushroom Cultivation**  
**BOTSC506**

**Course Outcome:**

1. Remember the history and scope of mushroom cultivation
2. Understand the economic importance of mushroom cultivation
3. Apply the basic tools and techniques used in mushroom cultivation
4. Analyze about the cost benefit ratio, marketing in India and abroad and export value of Mushroom
5. Evaluate and measure about processing of edible mushrooms.
6. Generalize the skills for developing commercial enterprise of mushroom cultivation

Unit	Topic	No. of lecturers/ hrs (45)
1	Introduction, history. Nutritional and medicinal value of edible mushrooms; Poisonous mushrooms. Types of edible mushrooms available in India – Volvariella volvacea, Pleurotus citrinopileatus, Agaricus bisporus	10
2	Cultivation methods: Infrastructure: substrates (locally available) Polythene bag, vessels, Inoculation hook, inoculation loop, low cost stove, sieves, culture rack, mushroom unit (Thatched house) water sprayer, tray, small polythene bag. Pure culture: Medium, sterilization, preparation of spawn, multiplication. Mushroom bed preparation - paddy straw, sugarcane trash, maize straw, banana leaves. Factors affecting the mushroom bed preparation - Low cost technology, composting technology in mushroom production	15
3	Storage and nutrition: Short-term storage (Refrigeration - upto 24 hours) Long term Storage (canning, pickels, papads), drying, storage in salt solutions. Nutrition - Proteins - amino acids, mineral elements nutrition - Carbohydrates, Crude fibre content - Vitamins.	10
4	Food Preparation : Types of foods prepared from mushroom. Research Centres - National level and Regional level. Cost benefit ratio - Marketing in India and abroad, Export Value.	10

**Suggested Readings**

- Tewari, Pankaj Kapoor, S.C., (1988). Mushroom cultivation, Mittal Publications, Delhi.
- Nita Bahl (1984-1988) Hand book of Mushrooms, II Edition, Vol. I & Vol.II.
- Suman, B.C. and Sharma, V.P. 2007 Mushroom Cultivation in India, Daya Books p179.
- D.P. Tripathi. 2023. Mushroom Cultivation. CBS Publishers and Distributors Pvt. Ltd. P368.

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**SEMESTER-VI**  
**Herbal Technology**  
**BOTSC606**

**Course Outcome:**

1. Remember and define role of medicinal plants, their cultivation, harvesting, processing, storage, marketing and utilization.
2. Understand uses of herbs in curing various ailments.
3. Explain phytochemistry of medicinal plants.
4. Analyze the systematic position and medicinal uses of some important plants like Tulsi, Ginger, Fenugreek, Indian Goose Berry and Ashoka.
5. Evaluate drug adulteration- types and methods of drug evaluation biological testing of herbal drugs for secondary metabolites
6. Plan or prepare to cultivate medicinal plants in lab through micropropagation

Unit	Topic	No. of lecturers/ hrs (45)
1	Herbal medicines: history and scope - definition of medical terms - role of medicinal plants in Ayurveda/Siddha systems of medicine; cultivation - harvesting - processing - storage - marketing and utilization of medicinal plants.	8
2	Pharmacognosy - systematic position medicinal uses of the following herbs in curing various ailments; Tulsi, Ginger, Fenugreek, Indian Goose berry and Ashoka	8
3	Phytochemistry - active principles and methods of their testing - identification and utilization of the medicinal herbs; Catharanthus roseus (cardiotonic), Withania somnifera (drugs acting on nervous system), Clerodendron phlomoides (anti-rheumatic) and Centella asiatica (memory booster).	12
4	Analytical pharmacognosy: Drug adulteration - types, methods of drug evaluation - Biological testing of herbal drugs - Phytochemical screening tests for secondary metabolites (alkaloids, flavonoids, steroids, triterpenoids, phenolic compounds)	13
5	Medicinal plant banks micro propagation of important species (Withania somnifera, neem and tulsi- Herbal foods-future of pharmacognosy)	4

**Suggested Reading**

1. Glossary of Indian medicinal plants, R.N.Chopra, S.L.Nayar and I.C.Chopra, 1956. C.S.I.R, NewDelhi.
2. Herbal plants and Drugs Agnes Arber, 1999. Mangal Deep Publications
3. Ayurvedic drugs and their plant source. V.V. Sivarajan and BalachandranIndra 1994. Oxford IBH publishing Co.
4. Verma, C.P.S., Kumar, S., Sehajpal, S., Sharma, I. and Sharma, K.T.2023. Text Book of Herbal Technology. Walnut Publication. P187.
5. Neelesh Malviya and Sapna Malviya. 2019. Herbal Drug Technology. CBS Publisher and Distributor. P256.

**DISSERTATION  
SEMESTER-VII & VIII**

**Dissertation on Major Core/Minor Elective (from VII & VIII Semester papers)  
OR Academic Project/ Entrepreneurship**

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**Course Outcome:**

1. Recite the subject knowledge.
2. Discuss and understand the scientific temperament.
3. Apply the fundamentals of research methodology.
4. Focus on the skills for the writing of thesis and scientific papers
5. Justify the knowledge of course work.
6. Create awareness and interest towards research.

**Course contents:** The student will be reading and analyzing published literature in the chosen area of plant science under direct mentoring of a faculty member and will participate in research activity

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# **SHRI GURU RAM RAI UNIVERSITY**

[Estd. by Govt. of Uttarakhand, vide Shri Guru Ram Rai University Act no. 03 of 2017 & recognized by UGC u/s (2f) of UGC Act 1956]



## **SYLLABUS FOR Master of Science (Botany) School of Basic & Applied Sciences**

(w.e.f 2023-2024)

**SHRI GURU RAM RAI UNIVERSITY, PATELNAGAR, DEHRADUN-  
UTTARAKHAND-248001**

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## Master of Science (Botany)

### Programme outcome (POs)

The student will be able to:

PO 1	In depth understanding of operational aspects, principles and objectives of botany and Allied Sciences.
PO2	Understand ethical issues, academic and research ethics, the need and value of lifelong learning, and the scientific misconduct of a scientist to serve society.
PO3	Understand the contribution of scientific knowledge in environmental contexts for sustainable development.
PO4	Demonstrate the professional botanical solutions in societal and environmental contexts, with the knowledge and need for sustainable development
PO5	Identify the situation-based problems, formulation, and action is taken based on analytical thinking and principles of science
PO6	Execute effective communication through interactive and presenting skills, technical report writings, and proper documentation of ideas.
PO7	Formulate, design, experimental techniques, scientific tools, analysis of scientific data, interpretation of data, and establish a hypothesis for various interdisciplinary research problems.
PO8	Enables individuals to function effectively in cross-cultural environments as an individual, and as a member or leaders.
PO9	Enhance and adopt employability skills through research, internship, and dissertation.
PO10	Implement strong theoretical and practical knowledge of botany to solve complex scientific problems
PO 11	Create a new conceptual, theoretical and operational approach to address various problems in interdisciplinary fields
PO12	Generate a culture of life-long learning in an inclined environment to achieve personal and enhance their employability for jobs in different sectors

### Program Specific Outcome (PSOs)

PSO 1	Knowledge about the basics and advanced aspects of cryptogamic botany.
PSO2	Understand different specializations of botany such as systematics, evolution, ecology, developmental biology, physiology, biochemistry, plant interactions with microbes and insects, morphology, anatomy, reproduction, genetics, cell & molecular biology of various life-forms.
PSO3	Learn, think and apply suitable methods to solve a wide range of problems in various analytical techniques of plant biology, use of plants as industrial resources or as human livelihood support system, transgenic technologies for basic and applied research in plants.
PSO4	Identify various life forms of plants, design and execute experiments related to basic and applied studies.
PSO 5	Evaluating the efficiency of various technologies and developing entrepreneurial and job-oriented skills needed in research, consultancy, forest service and industry



**Eligibility for admission:**

Any candidate who has passed the B. Sc. with Botany as one of the subject with not less than 45% marks in aggregate is eligible for admission; However, SC/ST, OBC and other eligible communities shall be given relaxation as per University rules.

**Duration of the Programme:** 2 Years (Four semesters)

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

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

Core courses prescribed for every Semester shall be mandatory for all students registered for the Master's Program in Botany and shall carry minimum 66 credits. Besides this there shall be Elective courses offered in semester III and IV and shall carry a minimum of 20 credits. A self-study course would comprise of maximum 6 credits of which minimum 03 credits shall be mandatory which shall not be included while calculating grades. The student may choose self-study course semesters III. The self-study course shall be based on advanced topics.

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

In order to qualify for a two year master's degree, a student must acquire a minimum of 80 credits including a minimum of 20 credits in electives choosing at least two elective (leading to a minimum 11 credits) offered by other departments and one qualifying self-study course of minimum 03 credits.

**Dissertation is an elective one. The dissertation is to be allotted in the beginning of III Semester and would be submitted during the examination of the IV Semester. In lieu of dissertation any two of the given elective papers of 03 credits each and one lab course (of both elective papers) of 03 credits (total 10 credits) may be chosen by those students who secure less than 75% up to II semester level. The Dissertation may be allotted at the start of III semester to those students who secure 75% or more up to II semester level and the Dissertation would be submitted at the time of IV Semester practical examination.**

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**STUDY & EVALUATION SCHEME**  
**Choice Based Credit System**  
**Master of Science (Botany)**

**First Semester**

S. No	Course Category	Course Code	Course Name	Periods				Evaluation scheme		Subject Total
				L	T	P	C	Sessional (Internal)	External (ESE)	
Theory										
1	Core	MBOC101	Mycology and Microbiology	3	0	0	3	40	60	100
2	Core	MBOC102	Phycology and Bryology	3	0	0	3	40	60	100
3	Core	MBOC103	Pteridology, Gymnosperm and Palaeobotany	3	0	0	3	40	60	100
4	Core	MBOC104	Taxonomy and Diversity of Flowering Plants	3	0	0	3	40	60	100
Practical										
1	Core	MBOL105	Laboratory Course I Based on C101&C102	0	0	4	4	40	60	100
2	Core	MBOL106	Laboratory Course II Based on C103&C104	0	0	4	4	40	60	100
<b>Total</b>				12		8	20	240	360	600

L – Lecture, T – Tutorial, P – Practical, C – Credit

**Second Semester**

S. No.	Course Category	Course Code	Course Name	Periods				Evaluation scheme		Subject Total
				L	T	P	C	Sessional (Internal)	External (ESE)	
Theory										
1	Core	MBOC201	Plant Development and Reproductive Biology	3	0	0	3	40	60	100
2	Core	MBOC202	Resource Utilization, IPR and Ethnobotany	3	0	0	3	40	60	100
3	Core	MBOC203	Cytogenetics and Molecular Biology	3	0	0	3	40	60	100
4	Core	MBOC204	Plant Breeding and Biostatistics	3	0	0	3	40	60	100
Practical										
1	Core	MBOL105	Laboratory Course I Based on C101&C102	0	0	4	4	40	60	100
2	Core	MBOL106	Laboratory Course II Based on C103&C104	0	0	4	4	40	60	100

<b>Total</b>	12		8	20	240	360	600
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L – Lecture, T – Tutorial, P – Practical, C – Credit

**Third Semester**

S. No.	Course Category	Course Code	Course Name	Periods				Evaluation scheme		Subject Total
				L	T	P	C	Sessional (Internal)	External (ESE)	
Theory										
1	Core	MBOC301	Plant Physiology and Biochemistry	3	0	0	3	40	60	100
2	Core	MBOC302	Ecology and Remote Sensing	3	0	0	3	40	60	100
3	Elective-I	MBOE304/305	Palynology and Pollination Biology/Fresh water algal flora of Himalaya	3	0	0	3	40	60	100
4	Elective-II	MBOE306/307	Plant Health Management/ Environment microbiology	3	0	0	3	40	60	100
Practical										
1	Core	MBOL 303	Laboratory Course – I Based on C301&C302	0	0	4	4	40	60	100
2	Elective	MBOL308	Laboratory course-II Based on E304/305/306/307	0	0	4	4	40	60	100
3	Self-study qualifying Not included while calculating grade	MBOS309/310/311	Forest Ecology/Introduction to medicinal and aromatic plants/ Pathogens and pests of crop plants	3	0	0	3	40	60	100
<b>Total</b>				12	0	8	20	240	360	600

L – Lecture, T – Tutorial, P – Practical, C – Credit

**Self-study marks not to be included while calculating grades.**

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**Fourth Semester**

S. No.	Course Category	Course Code	Course Name	Periods				Evaluation scheme		Subject Total
				L	T	P	C	Sessional (Internal)	External (ESE)	
Theory										
1	Core	MBOC401	Conservation Biology	3	0	0	3	40	60	100
2	Core	MBOC402	Biotechnology and Genetic Engineering of Plants and Microbes	3	0	0	3	40	60	100
3	Elective	MBOE404	Dissertation	0	0	10	10	60	240	300
<b>Note: In lieu of dissertation following elective papers and their practical may be chosen</b>										
4	Elective	MBOE405	Environment Management with Reference to Western Himalaya/	3	0	0	3	40	60	100
5	Elective	MBOE406	Seed Pathology	3	0	0	3	40	60	100
Practical										
1	Core	MBOL403	Laboratory Course – I Based on C401&C402	0	0	4	4	40	60	100
2	Elective	MBOL407	Laboratory Course II Based on E405/406	0	0	4	4	40	60	100
3	Self-Study	MBOS 408/409	Analytical Techniques in Plant Sciences/ Nursery and Gardening	3	0	0	3	40	60	100
<b>Total</b>				6+6	0	10+8	20	180+240	340+360	600

L – Lecture, T – Tutorial, P – Practical, C – Credit

**Total Credits = 80 (Core Credits 60 + Elective Credits 20) with additional 3 Credits of Self Study\***

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

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

**Examination Scheme:**

Components	I <sup>st</sup> internal Assignment/Presentation-I	II <sup>nd</sup> Internal Written/Attendance/Presentation-II	External (ESE)
Weightage (%) Theory/Practical	20 Marks	20 Marks	60
Weightage (%) Dissertation	30 Marks	30 Marks	240

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### Master of Science (Botany)

<b>Course code</b> : MBOC 101				
<b>Course Name</b> : Mycology and Microbiology				
<b>Semester /Year</b> : I				
	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
	3	0	0	3

L - Lecture T – Tutorial P – Practical C – Credit

**Course Objectives: The objectives of this course are**

1. The course aims to provide students with an understanding of general microbiology, contribution of microbiology to human life for various daily needs. The knowledge is used in health care for prevention of diseases, diagnosis, sterilization methods and drug production. Further, the knowledge is also extended into food production, production of alcohol, in agriculture, leather industry etc.
2. Discuss the importance of fungi in various ecological roles. Demonstrate an understanding of how fungi impact human affairs. Outline the higher taxonomy of the fungi and how the fungi relate to other organisms. Discuss the characteristics of the major classes and orders within the fungal kingdom. Identify the major families and certain species of mushrooms and other macro fungi and demonstrate a working knowledge of how fungi grow and reproduce, and where and how they can be isolated.

**Course contents**

**Unit 1-** History of Mycology; India and abroad, General characters of Fungi: Substrate relationship in fungi; Cell ultra-structure; unicellular and multi cellular organization, nutrition (saprobic, biotrophic, symbiotic); reproduction (vegetative, asexual, sexual); Recent trends in the classification. Phylogeny of Fungi; General account of *Mastigomycotina*, *Zygomycotina*, *Ascomycotina*, *Basidiomycotina*, *Deuteromycotina*; Fungi in industry, medicine and as food. Mycorrhizal Fungi as biocontrol agents. (No. of Hours: 12)

**Unit 2-** Symptoms, causal organisms of plant pathogens belonging to various fungal sub-division i.e. *Mastigomycotina*, *Zygomycotina*, *acomycotina*, *basidiomycotina* and *deuteromycotina*. (No. of Hours: 10)

**Unit 3-** A brief history of Microbiology, the diversity of micro-organisms, microbial growth. Archaeobacteria and Eubacteria: General account; ultrastructure, nutrition and reproduction; biology and economic importance; Cyanobacteria- classification, salient features and economic importance. (No. of Hours: 9)

**Unit 4-** Viruses: Characteristics; isolation and purification of viruses; chemical nature, replication, Transmission of viruses; economic importance. Phytoplasma: General characteristics and role in causing plant diseases. (e.g. sandal spike disease, sesamumphyllody, little leaf of brinjal). (No. of Hours: 8)

**Unit 5-** Immunology: Structure of antigens and antibodies, antigen-antibody reaction, Mechanism of antigen-antibody reactions. Vaccines and toxoids, Hypersensitivity. (No. of Hours: 6)

### Course outcomes (COs):

Upon successful completion of the course a student will be able to

CO1	Recall the knowledge about the history, concept and scope of mycology & Microbiology.
CO2	Understand the general characters and structural organization of Fungi and Microbes.
CO3	Explain and think about the symptoms and causal organisms of various fungal diseases of plants.
CO4	Analyze the importance of the characteristics, mode of reproduction and economic importance of Viruses and update the knowledge of basic of immunology.
CO5	Summarized the basic concept of fungi and microbes borne diseases.
CO6	Generalized the knowledge about the Mycology and Microbiology.

### Text Books:

1. Ainsworth, G.C. 1971. Ainsworth and Bisby's Dictionary of Genera of Fungi. Central Myco. Inst. Kew, Surrey. UK.
2. Alexopoulos, C.J., Mims, C.W. and Blackwell, M. 1996. Introductory Mycology. John Willey & Sons Inc.
3. Bilgrami, K.S. 1982. Physiology of Fungi. Bishen Singh Mahendra pal Singh, Dehradun.
4. Clifton, A. 1958. Introduction to the Bacteria. McGraw-Hillbook Co., NewYork.
5. Mandahar, C.L. 1978. Introduction to Plant Viruses. Chand & Co. Ltd., Delhi.
6. Mehrotra, R.S. and Aneja, R.S. 1998. An Introduction to Mycology. New Age Intermediate Press.
7. Webster, J. 1985. Introduction to Fungi. Cambridge University Press.
8. Doelle, H.W. and C.G, Heden 1986. Applied Microbiology, Kluwer Academic Press, London.

### Reference Books:

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

2. Ross, F.C. 1983. Introductory Microbiology. Charles E. Merri l. Publ. Co. Columbus, Ohio.
3. Alexander, M.1991. Microbial Ecology. John Wiley and Sons. NewYork.
4. APHA.1971.StandardMethodsfortheExaminationofwaterandWasteWater.Washington DC
5. Atlas. R. M. Principle of Microbiology.
6. Board,R.G. and D.W.,Lovelock1975. Some Method for Microbiological Assay. Acadmic Press. NewYork
7. Casida, L. E. 1968. Industrial Microbiology. John Wiley and Sons, NewYork.
8. Clifford, H.T. and W. Stephenson 1975. An Introduction to Numerical Classification, Academic press, NewYork.

**CO-PO Mapping**

Course	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3	PS O4
CO1	2	3	....	2	2	.....	...	1	2	1	....	3	3	3	....	2.
CO2	3	...	2	3	3	2	2	1	3	2	2	3	1	1.	2	2.
CO3	2	2	2	2	2	.....	3	2	2	3	1	2	1	1.	2	3.
CO4	1	3	2	2	2	.....	...	1	3	2	2	2	2	3	....	1.
CO5	2	3	2	....	2	.....	3	1	3	2	...	1	2	3.	.....	3
CO6	3	2	1	2	3	2	2	2	3	2	2	1	3	2	2	3

3: Highest Correlated, 2: Medium Correlated, 1: Lowest Correlated

<b>Course code</b> : MBOC 102				
<b>Course Name</b> : Phycology and Bryology				
<b>Semester /Year</b> : I				
	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
	3	0	0	3

L - Lecture T – Tutorial P – Practical C – Credit

**Course Objectives: The objectives of this course are**

1. To develop understanding about core concept of occurrence, distribution or diversity, evolution and life history of lower plants.
2. To increase the understanding of students about the identification, classification, structure and growth and economic importance algae and bryophytes.

**Course contents**

**Unit 1-** Algal habitats, Algal Classification, Criteria for classification of algae: pigments, reserve food and flagella, Thallus organization, cell structure and reproduction (vegetative, asexual and sexual), Phylogeny and interrelationships of algae.

(No. of Hours: 8)

**Unit 2-** Classification and salient features of Chlorophyta, Charophyta, Xanthophyta, Bacillariophyta, Phaeophyta, Rhodophyta and Cyanophyta.

(No. of Hours: 12)

**Unit 3-** Nitrogen fixating algae, parasitic algae, Economic importance of Algae, Algal blooms, algal Biofertilizers, algae as food, feed and uses in industry.

(No. of Hours: 3)

**Unit 4-** Morphology, structure reproduction, life history and Classification of Bryophyta, Ecology of bryophytes, their association with other organisms, Fossil bryophytes, general account, Knowledge of the distribution of bryophytes in the Himalaya.

(No. of Hours: 10)

**Unit 5-** General account of Marchantiatales, Jungermanniales, Calobryales, Sphaerocarpaceae and Anthocerotales, Sphagnales, Andreales, Funariales and Polytrichales.

(No. of Hours: 12)

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**Course outcomes (COs):**

Upon successful completion of the course a student will be able to

CO1	Remember about the habitats of algae and bryophyte, their general characters, classification, occurrence, reproduction.
CO2	Understand about the thallus organization, cell structure, classification and reproduction and economic importance of algae.
CO3	Explain the classification, phylogeny, morphology, structure reproduction, life history and economic importance of algae and Bryophytes.
CO4	Explain the applications of algae and bryophytes with their uses.
CO5	Develop skills related to laboratory as well as industries based studies
CO6	Express the knowledge related to algae and Bryophytes.

**Suggested Textbooks**

1. Cavers, F. 1979. The Inter-relationships of the Bryophytes Reprint. Bishen Singh Mahendra pal Singh, Dehradun.
2. Fritsch, F.E. 1979. The Structure and Reproduction of Algae. Reprint. Bishen Singh Mahendra pal Singh, Dehradun.
3. Kashyap, S.R. 1968. Liverworts of the Western Himalayas and Punjab Plains. The Chronica Botanic Co. Delhi.
4. Kumar, H.D. 1988. Introductory Phycology. Affiliated East-West Press Ltd., New Delhi.
5. Morris, I. 1986. An Introduction to the Algae. Cambridge University Press, U.K.
6. Parihar, N.S. 1991. Bryophyta. Central Book Depot, Allahabad.

**Reference Books**

1. Prescott, G.W. Algae: A Review. Bishen Singh Mahendra pal Singh.
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. Round, F.E. 1986. The Biology of Algae. Cambridge University Press, Cambridge.
5. Smith, G. M. 1955. Cryptogamic Botany. Vol. I and II. Tata McGraw Hill, New Delhi.
6. Stewart, W.N. and Rathwell, G.W. 1993. Paleo botany and the Evolution of Plants. Cambridge University Press.

**Indian authors:**

1. Vashishta, B.R. 1991. Botany for degree students. Bryophytes 8<sup>th</sup> ed. S. Chand and Co. Ltd. Delhi.
2. B.N. Vashishta, B.R., A.K. Sinha and A. Kumar. 2010. Algae. S. Chand and Co. Ltd. Delhi.

**CO-PO Mapping**

Course	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PSO 3	PSO4
CO1	1	2	....	....	1.	....	...	1	3	2	...	2.	1	2	1	3
CO2	...	1	....	....	2	....	2	...	2	....	2	3	2	3	2	2
CO3	...	1	....	....	2	....	2	....	2	1.	2	3.	2	2	3	1
CO4	...	3	....	2	1	....	...	...	2	3	2	2	3	3	2	2
CO5	2	2	....	2	3	2	....	2	3	3	1	2	3	2	3	2
CO6	2	3	....	2	2	2	2	3	1	3	2	2	2	1	1	3

3: Highest Correlated, 2: Medium Correlated, 1: Lowest Correlated

<b>Course code</b>	: MBOC 103			
<b>Course Name</b>	: Pteridology, Gymnosperm and Palaeobotany			
<b>Semester /Year</b>	: I			
	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
	3	0	0	3

L - Lecture T – Tutorial P – Practical C – Credit

**Course Objectives: The objectives of this course are**

1. The course focuses on morphology, anatomy, reproduction and evolution in Pteridophytes and Gymnosperms.
2. Develop the basic understanding of important characteristics, anatomy, reproduction and evolution along with economic importance of these two groups and Palaeobotany

**Course contents**

**Unit 1-** History, origin, classification, present and past distribution, morphology and life history of **Psilophyta**: Psilophytales (*Psilophyton*) and Psilotales (*Psilotum*). Lycophyta: Lepidodendrales (*Lepidodendron*), Lycopodiales (*Phylloglossum*), Lepidospermales (*Lepidocarpon*) and Isoetales (*Isoetes*). Sphenophyta: Hyeniales, Sphenophyllales and Calamitales. Pterophyta: Ophioglossales, Osmundales, Filicales and Salviniiales. **(No. of Hours: 18)**

**Unit 2-** Classification and distribution of Gymnosperms in India with special reference to Himalaya region. Morphology, structure and life-history of Pteridospermales: Palaeozoic and Mesozoic groups with references to Lyginopteridaceae (*Lyginopteris*) and Medullosaceae (*Trigonocarpus*). **(No. of Hours: 8)**

**Unit 3-** A general account of Glossopteridaceae. Bennettiales: A general account of Cycadeoidaceae, William soniaceae and Wielandiellaceae. Cycadales: A detailed account including distribution of living Cycads. **(No. of Hours: 8)**

**Unit 4-** A general account of Pentoxylales, Cordaitales, Ginkgoales (*Ginkgo*), Ephedrales, Welwitschiales and Gnetales. A general account of fossil and living Coniferales and Taxales. Economic importance of Gymnosperms. **(No. of Hours: 6)**

**Unit 5-** Definition of fossil, different types of plant fossil as per their mode of preservation, concept of form genus. Indian Gondwana Sequence, Introductory idea of Continental Drift Hypothesis. **(No. of Hours: 5)**

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**Course outcomes (COs):****Upon successful completion of the course a student will be able to**

CO1	Remember the history, origin, classification of pteriphytes and Gymnosperms in India with special reference to Himalaya.
CO2	Understand the history origin, classification, distribution, morphology and life history of Pterophyta and Fossil Pteridophyte.
CO3	Explain Illustrate and design the morphology, structure and life history of and Gymnosperms and their economic importance.
CO4	Analyze the scope of Pteridophyte, gymnosperms Paleobotany, types of fossils, its role in global economy and geological time scale.
CO5	Summarized the history, origin, classification of pteriphytes and Gymnosperms.
CO6	Express the knowledge related to Pteridophyte and gymnosperms.

**Suggested Textbooks**

1. Andrews, HN. 1961. Studies in Palaeobotany. New York.
2. Baker, J.G. 1995. Hand book of the Fern Allies .Reprint. Bishen Singh Mahendra Pal Singh, Dehradun.
3. Bhatnagar, S.P. and Mitra, A.1996. Gymnosperms. New Age International Pvt. Ltd., New Delhi.
4. Beddome, R.H. 1966. The Ferns of British India. 2Vols. Oxford and IBH, NewDelhi.
5. Chamberlain, C.J. 1955. Gymnosperms: Structure and Evolution. Chicago.
6. Eams, A.J. 1969. Morphology of Lower Vascular Plants.
7. Parihar, N.S. 1996. Biology & Morphology of Pteridophytes. Central Book Depot Allahabad.

**Reference Books**

1. Raizada, M.B and Sahni, K.C. 1958. Living Indian Gymnosperms.
2. Sahni, K.C. 1996. Gymnosperms of India and Adjacent Countries. Bishen Singh Mahendra pal Singh, Dehradun.
3. Seward, A.C. 1919. Fossil Plants for Students of Botany and Geology. 4Vols. Cambridge.
4. Sporne, K.R. 1991.The Morphology of Pteridophytes. Hutchinson Library Series London.
5. Sporne, K.R. 1991.The Morphology of Gymnosperms. Hutchinson Library Series London

**CO-PO Mapping**

Course	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3	PS O4
CO1	...	2	....	2	1	1	...	2	3	2	1	2	3	2	...	....
CO2	2	...	1	....	3	2	2	...	3	2	1	2	3	....	3	3
CO3	1	...	....	2	3	.....	2	2.	2	3	2	2	3	....	3	2
CO4	...	3	1	3	2	2	...	...	2	3	2	2	2	3	2	....
CO5	3	2	2	3	2	2	2	3	2	2	1	2	2	...	2	3
CO6	3	2	3	2	2	2	2	3	2	2	1	2	2	1	2	3

3: Highest Correlated, 2: Medium Correlated, 1: Lowest Correlated

<b>Course code</b>	: MBOC 104			
<b>Course Name</b>	: Taxonomy and Diversity of flowering Plants			
<b>Semester /Year</b>	: I			
	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
	3	0	0	3

L - Lecture T – Tutorial P – Practical C – Credit

**Course Objectives: The objectives of this course are**

This course aims to add to understanding of the students about the diversity of plants, their Description, Identification, Nomenclature and their classification including recent advances in the field.

**Course contents**

**Unit 1-** Origin of intra-population variation: Population and the environment; ecads and ecotypes; evolution and differentiation of species- various models. The species concepts; taxonomic hierarchy, species, genus, family and other categories; principles used in assessing relationship, delimitation of taxa and attribution of rank. **(No. of Hours: 8)**

**Unit 2-** Salient features of the International Code of Botanical Nomenclature. Taxonomic evidences and Taxonomic tools: anatomy, palynology, embryology, Photochemistry, histological, serological and molecular-techniques. Herbarium and Botanical gardens: General account. **(No. of Hours: 7)**

**Unit 3-** Systems of angiosperm classification: Phenetic versus phylogenetic systems; cladistics sin taxonomy; major systems of classification (Bentham and Hooker, Hutchinson, Cronquist) and their relative merits and demerits. **(No. of Hours: 8)**

**Unit 4-** A study of the following families and their relationships: **(No. of Hours: 20)**

- a. Dicotyledons: Magnoliaceae, Berberidaceae, Fumariaceae, Violaceae, Meliaceae, Apiaceae, Sterculiaceae, Tiliaceae, Geraniaceae, Asteraceae, Campanulaceae, Ericaceae, Primulaceae, Asclepiadaceae, Convolvulaceae, Verbenaceae, Scrophulariaceae, Oleaceae, Amaranthaceae, Loranthaceae, Urticaceae, Juglandaceae, Salicaceae and Fagaceae
- b. Monocotyledons: Hydrocharitaceae, Orchidaceae, Amaryllidaceae, Araceae, Poaceae and Cyperaceae

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

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**Unit 5-** Plant exploration in India with reference to North West and Uttarakhand Himalaya.  
Status of flowering plant diversity in Garhwal Himalaya region. (No. of Hours: 2)

### Course outcomes (COs):

Upon successful completion of the course a student will be able to

CO1	Remembering the depth knowledge salient features of angiosperms, concept of origin and evolution of angiosperms.
CO2	Understanding various systems of classifications and its salient features
CO3	Familiarized with the salient features of ICBN/ICN species concept, taxonomic hierarchy, and delimitation of taxa and attribution of rank.
CO4	Analyse the plants and describe them taxonomically
CO5	Summarized the skills in Plant inventory and exploration, identification and its conservation
CO6	Acquaint with basic concept of plant taxonomy with reference to flowering plants.

### Suggested Textbooks

1. Babu, C.R. 1976. Herbaceous Flora of Dehradun. CSIR, New Delhi.
2. Cronquist, A. 1981. An Integrated System of Classification of Flowering Plants. Columbia University Press, New York.
3. Gaur, R.D. 1999. Flora of District Garhwal: NW Himalaya. Transmedia, Srinagar, Garhwal.
4. Hutchinson, J. 1973. The Families of Flowering Plants. 2 Vols. Oxford University Press, Oxford.
5. Jain, S.K. and Rao, R.R. 1977. A handbook of Field and Herbarium methods. Today and Tomorrow, New Delhi.
6. Lawrence, H.W. 1951. Taxonomy of Vascular Plants. Reprint Oxford and IBH, New Delhi.

### Reference Books

1. Naithani, B.D. 1985. Flora of Chamoli. 2 Vols, BSI, Calcutta.
2. Nordenstam, B., El Gazaly, G. and St Kassas, M. 2000. Plant Systematic for 21 Century. Portlant Press Ltd., London.
3. Radford, A.E. 1986. Fundamentals of Plant Systematics. Harper & Row Publications, USA.
4. Singh, H. 1978. Embryology of Gymnosperms. Encyclopaedia of Plant Anatomy X. Gebruder Bortraeger, Berlin.
5. Odum E.P. 2009. Fundamental of Ecology. McGraw Hill Pub.
6. Singh H.R. and Kumar. 2008. Ecology and Environmental Science. Vishal Publishing Co.
7. Stace, C.A. 1989. Plant Taxonomy and Biosystematics (2edition).Edward Arnold Ltd., London.
8. Takhtajan, A.L. 1997. Diversity and Classification of Flowering Plants. Columbia University Press, New York.

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**CO-PO Mapping**

Course	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3	PS O4
CO1	...	2	....	2	1	1	...	2	3	2	1	2	3	2	...	....
CO2	2	...	1	....	3	2	2	...	3	2	1	2	3	....	3	3
CO3	1	...	....	2	3	....	2	2.	2	3	2	2	3	....	3	2
CO4	...	3	1	3	2	2	...	...	2	3	2	2	2	3	2	....
CO5	3	2	2	3	2	2	2	3	2	2	1	2	2	...	2	3
CO6	3	2	3	2	2	2	2	3	2	2	1	2	2	1	2	3

3: Highest Correlated, 2: Medium Correlated, 1: Lowest Correlated

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<b>Course code</b>	: MBOL 105			
<b>Course Name</b>	: Laboratory Course-I			
<b>Semester /Year</b>	: I			
	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
	0	0	4	4

L - Lecture T – Tutorial P – Practical C – Credit

#### Course contents

1. Study of representative genera of Zygomycotina, Ascomycotina, Basidiomycotina and Deuteromycotina.
2. Symptomatology of at least one diseased specimen of plant pathogens belonging to various fungal sub-division i.e. *Mastigomycotina*, Zygomycotina, acomycotina, basidiomycotina and deuteromycotina, bacteria and viruses.
3. Aseptic methods and demonstration of instruments viz., autoclave, hot air oven, incubator, laminar airflow.
4. Direct examination of root nodule bacteria under microscope and isolation of *Rhizobium* in root nodules.
5. Isolation and enumeration of microbes from natural samples (soil and water) by agar plate technique.
6. Morphological study of representative members of algae: *Microcystis*, *Lyngbya*, *Cylindrospermum*, *Gloeotrichia*, *Scytonema*, *Pandorina*, *Eudorina*, *Scendesmus*, *Pediastrum*, *Hydrodictyon*, *Ulva*,
7. *Enteromorpha*, *Drapernaldiopsis*, *Stigeoclonium*, *Fritschiella*, *Coleochaete*, *Bulbochaete*, *Cosmarium*, *Caulerpa*, *Nitella*, *Dictyota*, *Gelidium*, *Gracillaria*, *Batrachospermum* and *Polysiphonia*.
8. Study and identification with suitable preparations of *Ricciocarpus*, *Targionia*, *Cyathodium*, *Plagiochasma*, *Asterella* (*Fimbriaria*), *Dumortiera*, *Sewardiella*, *Pellia*, *Fossombronia*, *Porella*, *Calobryum*, *Notothylas*, *Sphagnum*, *Polytrichum* and *Funaria*

#### Course outcomes (COs):

Upon successful completion of the course a student will be able to

<b>CO1</b>	Recall the knowledge of different genera belong to different classes of fungi, algae and bryophytes.
<b>CO2</b>	Understanding about different instruments and lab safety rules.
<b>CO3</b>	Illustrate the methods of isolation and identification.
<b>CO4</b>	Analyze the agar plate technique for isolation, enumeration and identification of microbes.
<b>CO5</b>	Reframe the identification and Isolation of fungi, Algae and Bryophytes.
<b>CO6</b>	Assemble the knowledge of media preparation, Isolation and identification fungi, Algae and Bryophytes

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**Suggested Textbooks**

1. B.P. Pandey. (2019). Practical Botany-Revised ed. S. Chand Co. Ltd. Delhi
2. Yadav, S. (2022). Plant Systematics with Practical. Mahaveer Publication.

**Reference Book**

1. S. Sundara Rajan. (2003). Practical Manual of Plant Morphology (Algae, Fungi, Bryophytes and Angiosperms). Anmol Publications.

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<b>Course code</b>	: MBOL 106			
<b>Course Name</b>	: Laboratory Course-II			
<b>Semester /Year</b>	: I			
	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
	0	0	4	4

L - Lecture T - Tutorial P - Practical C - Credit

### Course contents

Study and identification with suitable preparations of the following:

#### A. PTERIDOPHYTES

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

#### B. GYMNOSPERMS

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

#### C. PALAEOBOTANY

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

#### D. TAXONOMY

1. Identification and description of locally available plants belonging to families included in the syllabus from fresh specimens, herbarium or preserved materials. After identification up to family level any suitable regional Flora may be provided for generic identification if required.
2. Description of a species based on various specimens to study intra specific variation.
3. Studies of Indore the location of key characters and preparation of keys at generic level.
4. Field trips, compilation of field notes, the preparation of herbarium sheets and submission of herbarium and museum specimens and/or live potted specimens of taxonomic interest and submission of the excursion report.

### Course outcomes (COs):

Upon successful completion of the course a student will be able to

CO1	Recall the knowledge of different genera which belong to different classes and orders of Pteridophyte and Gymnosperms, Angiosperm and fossil plants.
CO2	Gain Understanding about morphology of plants through live potted specimens.
CO3	Apply the methods of identification with the help of keys and flora.
CO4	Execute and apply the herbarium preparation and to enhance their knowledge regarding conservation of plants through field trips.
CO5	Justify the knowledge of Pteridophyte and Gymnosperms, Angiosperm and fossil plants.
CO6	Report preparation of Field trips, compilation of field notes, the preparation of museum specimens and/or live potted specimens of taxonomic interest and submission of the excursion report

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**Suggested Textbooks**

1. Bhavnagar, S.P. and Moitra, A. (2020). Gymnosperms. New Age International (P) Ltd. Publisher, P480.
2. O.P. Sharma. (2017). Pteridophyte. McGraw Hill Education.
3. Rajan Sundara, S. (2021). Practical Manual of Angiosperm Taxonomy. Anmol Publication Pvt. Ltd.

**Reference Book**

1. Chitranjan Mohanty. (2018). Bryophytes, Pteridophyte, Gymnosperm and Palaeobotany. Kalyani Publisher.

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<b>Course code</b>	: MBOC 201			
<b>Course Name</b>	: Plant Development and Reproductive Biology			
<b>Semester /Year</b>	: II			
	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
	3	0	0	3

L - Lecture T – Tutorial P – Practical C – Credit

**Course Objectives: The objectives of this course are**

1. This course aims at making the students acquainted with the fundamentals and present understanding of the mechanisms associated with development and differentiation of various plant organs.
2. To know the various structural and anatomical components of plant tissue and reproductive parts and its taxonomic significance.

**Course contents**

**Unit 1-** Seed germination and seedling growth: Mobilization of food reserves; tropisms; hormonal control of seedling growth. Shoot development: Organization of the shoot apical meristem (SAM); cytological and molecular analysis of SAM; control of cell division and cell to cell communication. Root development: Organization of root apical meristem (RAM); cell fates and lineages; vascular tissue differentiation; lateral roots; root hairs; root-microbe interactions.

(No. of Hours: 12)

**Unit 2-** Leaf growth and differentiation: Origin, development and Phyllotaxy. Cambium and its functions: formation of secondary xylem; general account of wood structure in relation to conduction of water and minerals.

(No. of Hours: 6)

**Unit 3-** Reproduction: Vegetative options and sexual reproduction; flower-a modified shoot, structure, functions; structure of anther and pistil; Genetics of floral organ differentiation.

(No. of Hours: 4)

**Unit 4-** Malegametophyte: Structure of anthers; micro sporogenesis, role of tapetum; pollen development and gene expression. Female gametophyte: Ovule development; Megasporogenesis; organization of the embryo sac. Pollination, pollen-pistil interaction and fertilization: Pollen-stigma interactions, sporophytic and gametophytes self-incompatibility (cytological, biochemical and molecular aspects); double fertilization; *in vitro* fertilization.

(No. of Hours: 12)

**Unit 5-** Seed development and Fruit growth: Endosperm development; embryogenesis, polyembryony; Apomixis, biochemistry and molecular biology of fruit maturation. Latent life-Dormancy: Importance and types of seed dormancy; overcoming seed dormancy; bud dormancy. Senescence and programmed cell death (PCD): Basic concept, types of cell death, PCD in the life cycle of plant, metabolic change associated with senescence and its regulation;

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influence of hormones and environmental factors on senescence.

(No. of Hours: 11)

**Course outcomes (COs):****Upon successful completion of the course a student will be able to**

<b>CO1</b>	Remember the process of Plant Development and Reproductive Biology.
<b>CO2</b>	Understand the organization and differentiation of shoot with reference to SAM and RAM, male and female gametophyte, ovule structure.
<b>CO3</b>	Explain the reproduction process, Seed development and Fruit growth.
<b>CO4</b>	Analyzed the differentiation and arrangement of leaf, shoot and root.
<b>CO5</b>	Summarized the growth and development of root, shoot, leaf, and seed.
<b>CO6</b>	Generalized the developmental process and organization of plant reproductive organs.

**Suggested Textbooks**

1. Bhojwani, S.S. and Bhatnagar, S.P. 2000. The Embryology of Angiosperms (4th enlarged edition). Vikas Publishing House, New Delhi.
2. Eams, A.J. 1989. An Introduction to Plant Anatomy. Reprint. Bishen Singh Mahendra Pal Singh, Dehradun.
3. Maheshwari, P. 1950. An Introduction to Embryology of Angiosperms. McGraw Hill, New York.
4. Raghavan, V. 1999. Developmental Biology of Flowering Plants. Springer-Verlag, New York.

**Reference Books**

1. Bewley, J.D. and Black, M. 1994. Seeds: Physiology of Development and Germination. Plenum Press, New York.
2. Burgess, J. 1985. An Introduction to Plant Cell Development. Cambridge University Press, Cambridge.
3. Fageri, K. and Vander Pijl, L. 1979. The Principles of Pollination Ecology. Pergamon Press, Oxford.
4. Fahn, A. 1982. Plant Anatomy. (4th edition). Pergamon Press, Oxford.
5. Fosket, D.E. 1994. Plant Growth and Development. A Molecular Approach. Academic Press, San Diego.

**CO-PO Mapping**

Course	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3	PS O4
<b>CO1</b>	2	3	....	3	2	.....	...	2	3	2	...	.....	3	.....	3	2
<b>CO2</b>	2	...	2	2	3	2	1	2	3	....	3	3	2	2	2	3.
<b>CO3</b>	3	2	2	3	2	.....	2	3	3	....	3	2	2	....	2	2
<b>CO4</b>	...	3	2	2	3	.....	...	2	2	3	2	.....	3	2	1	3
<b>CO5</b>	2	2	2	....	2	.....	3	2	2	...	2	3	2	2	2	2.
<b>CO6</b>	3	2	....	3	2	2	2	3	2	1	2	3	2	3	3	2

3: Highest Correlated, 2: Medium Correlated, 1: Lowest Correlated

<b>Course code</b>	: MBOC 202			
<b>Course Name</b>	: Resource Utilization, IPR and Ethno botany			
<b>Semester /Year</b>	: II			
	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
	3	0	0	3

L - Lecture T – Tutorial P – Practical C – Credit

**Course Objectives: The objectives of this course are**

1. To apprise students of conventional and non-conventional plant resources being used by human, their effective and sustainable utilization and improvement.
2. Transforming the knowledge into skills for promotion of traditional medicine and conservation of plants.

**Course contents**

**Unit 1-** Plant resources: Concept, status, utilization and concerns. World Centers of Primary Diversity of domesticated plants Origin, evolution, botany, cultivation, cyto-taxonomy and uses of (i) Cereals and millets (wheat, paddy, maize), (ii) Legumes (soybean, black gram and cow peas), (iii) Sugar cane and starches (sugarcane, beetroot, potato, sweet potato, cassava), (iv) Forage and fodder Crops. Fiber crops, medicinal and aromatic.

(No. of Hours: 12)

**Unit 2-** Important fire wood and timber yielding plants and non-wood forest products (NWFPs) such as bamboos, gums, tannins, dyes, resins, beverages. Plants used as ornamentals and avenue trees.

(No. of Hours: 06)

**Unit 3-** Intellectual Property Rights, Concept, History, Protection of IPR; Patent-requirements, procedures and limitations; International convention on Biological Diversity.

(No. of Hours: 06)

**Unit 4-** Ethnobotany: Concept, linkage with other sciences, tools of ethnobotanical studies world and Indian perspective with special reference to the Himalayas, Green revolution: Benefits and adverse consequences.

(No. of Hours: 04)

**Unit 5-** Principles of conservation: Extinction; Status of plants based on International Union for Conservation of Nature (IUCN). Strategies for conservation: *In-situ* conservation; protected areas in India-sanctuaries, national parks and biosphere reserves.

(No. of Hours: 08)

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**Course outcomes (COs):****Upon successful completion of the course a student will be able to**

CO1	Remember and define the concepts of Plant resources its economic value and conservation
CO2	Understand, describe and classify the diversity and uses of plants in different aspects
CO3	Explain and Develop a basic knowledge of important families of useful plants.
CO4	Analyze the concept of IPR, various legal issues related to IPR.
CO5	Summarized the concept of ethno-botany and folk medicines.
CO6	Generalized the basic concepts if Resource Utilization, Conservation and Ethnobotany

**Suggested Textbooks**

1. P.C. Trivedi and Niranjana Sharma. (2017). Plant Resource Utilization and Conservation. Pointer Publication, Jaipur.
2. Chandel, K.P.S., Shukla, G. and Sharma, N.1996. Biodiversity in Medicinal and Aromatic Plants in India: Conservation and Utilization. National Bureau of Plant Genetic Resources, New Delhi.
3. Hill, A.F. 1952. Economic Botany. McGraw Hill., New York.
4. Kochar, S.L.1998. Economic Botany in the Tropics. MacMillan India Ltd. Delhi
5. Kothari, A. 1997. Understanding Biodiversity: Life Sustainability and Equity. Orient Longman.
6. Nair, M. N.B .et al. (Eds) 1998. Sustainable Management of Non-Wood forest Products. Faculty of Forestry, Universiti Putra Malaysia. 434004 PM Serdang, Selangor, Malaysia
7. Paroda, R.S. and Arora, R.K. 1991. Plant Genetic resources conservation and Management. IPGRI (Publication) South Asia Office, C/o NBPGR, Pusa Campus, New Delhi.
8. Rodgers, N.A. and Panwar, H.S. 1988. Planning a Wildlife Protected Area Network in India. Vol. 1. The Report. Wildlife Institute of India, Dehradun.

**Reference Books**

1. Baenzinger, S.P., Kleese, R.A. and Barns, R.F. 1993. Intellectual Property Rights, Protection of plant materials; executive summary and work group reports. CSSA Publication No. 21. Crop Science Soc. of America, Wisconsin, Madison.
2. Council of Scientific & Industrial Research (1948-1976). The Wealth of India. A Dictionary of Indian Raw Materials and Industrial Products. New Delhi. Raw Materials I-XII, Revised Volume I-III (1985-1992) Supplement (2000).
3. Council of Scientific & Industrial Research 1986. The Useful Plants of India. Publications and Information Directorate, CSIR, New Delhi.
4. Walter, K.S. and Gillet, H.J. 1998. IUCN Red List of Threatened Plants. IUCN The World Conservation Union. IUCN, Gland, Switzerland, and Cambridge, U.K.

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**CO-PO Mapping**

Course	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3	PS O4
CO1	3	...	2.	2	2	2	...	1	3	2	...	.....	3	2	3	2
CO2	1	3	2	2	1	2	2	2	3	2	3	3	2	2	2	3.
CO3	3	2	2	3	2	2	3	2	3	1	3	2	2	2.	2	2
CO4	2	1	2	2	2	...	1	3	2	3	2	.....	3	2	1	3
CO5	1	3	2	1	1	3	2	3	2	1	2	3	2	2	2	2.
CO6	3	3	2	3	1	2	2	2	...	3	2	3	2	3	3	2

3: Highest Correlated, 2: Medium Correlated, 1: Lowest Correlated

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<b>Course code</b>	: MBOC 203			
<b>Course Name</b>	: Cytogenetics and Molecular Biology			
<b>Semester /Year</b>	: II			
	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
	3	0	0	3

L - Lecture T – Tutorial P – Practical C – Credit

**Course Objectives: The objectives of this course are**

1. To understand the concept of Mendelian and non-Mendelian inheritance, quantitative genetics, molecular markers and linkage mapping, prokaryotic and eukaryotic genome-structure, gene function and regulation, epigenetic, Cytogenetics.
2. To provide a foundation and background in cellular and acellular entities of plants and animals, cell structure in relation to functions, eukaryotic genome structure (including nuclear and organellar), and regulatory mechanisms.

**Course contents**

**Unit 1-**The dynamic cell: Structural organization of the plant cell, specialized plant cell, Structure and functions of Cell wall, Structure, models and functions of Plasma membrane, sites for ATPases, ion carriers, channels and pumps, receptors. (No. of Hours: 8)

**Unit-2-** Structure, function and organization of Cell Organelles; Mitochondria, chloroplast, Nucleus (nuclear pores, nucleosome organization) and Ribosome (cyto-protein synthesis). (No. of Hours: 12)

**Unit 3-** Chromatin organization; Chromosome structure and packaging of DNA, molecular organization of centromere and telomere, euchromatin and heterochromatin, specialized types of chromosomes; Polytene, Lampbrush, B-chromosomes and sex chromosomes, DNA damage and repair mechanism, defects in DNA repair. (No. of Hours: 6)

**Unit 4-** Principles of inheritance: Mendelian laws along with molecular explanations, Exceptions to Mendelian laws, lethal alleles and Gene Interactions. Structural and numerical alterations in chromosomes, Aneuploids, Euploids, Trisomics and Monosomics. (No. of Hours: 7)

**Unit 5-** Genetics of prokaryotes and eukaryotic organelles, genetic transportation, conjugation and transduction in bacteria, regulation of gene expression in prokaryotes and eukaryotes. Initiation of cancer at cellular level, proto-oncogenes and oncogenes. crossing over, linkage groups, genetic markers, construction of molecular maps. Mutations: Spontaneous and induced mutations, physical and chemical mutation, molecular basis of gene mutation, mutations induced by transposons. (No. of Hours: 12)

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**Course outcomes (COs):**

**Upon successful completion of the course a student will be able to**

<b>CO1</b>	Describe the Cytogenetics and molecular biology and pattern of inheritance in various life forms.
<b>CO2</b>	Understand the fundamental basics of cell structure, inheritance and genetics on molecular level.
<b>CO3</b>	Apply the knowledge about the plant cell structure and their turn over, starting from cell wall to chromatin, in relation to their functions and Genetics of prokaryotes and eukaryotic organelles.
<b>CO4</b>	Explain the principle mechanisms of genome replication, maintenance, function and regulation of expression, Genetic recombination and genetic mapping with reference to prokaryotes and eukaryotic organelles of cells.
<b>CO5</b>	Summarized the knowledge of Cytogenetics and molecular biology in designing experiment, statistical analysis, and interpretation of results.
<b>CO6</b>	Generalized the concept of Cytogenetics and molecular biology

**Suggested Textbooks**

1. Barry, J. M. and Barry, B.M. 1973. Molecular Biology, Prentice Hall Of India New Delhi.
2. Buchanan, B.B., Gruissem, W, W, W. and Jones, R.L. 2000. Biochemistry and Molecular Biology of Plants. American Society of Plant Physiologists, Maryl and, USA.
3. De, D. N. 2000. Plant Cell Vacuoles: An Introduction. CSIRO Publication, Colling wood, Australia.
4. Gupta, P.K.1998. Cytogenetics. Rastogi Publications. Meerut.

**Reference Books**

1. Alberts, B., Bray, D., Lewis, J., Raff, M., Roberts, K. and Watson, J.D.1989. Molecular Biology of the Cell (2<sup>nd</sup> edition). Garland Publishing Inc., New York.
2. Atherly, A.G., Girton, J.R. and McDonald, J.F.1999.TheScienceofGenetics.Saunders College Publishing, Fort Worth, USA.
3. Burnham, C. R. 1962.Discussions in Cytogenetics. Burgess Publishing Co., Minnesota.
4. Busch, H. and Rothblum, L. 1982.Volume-X. The Cell Nucleus DNA Part-A. Academic Press.

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**CO-PO Mapping**

Course	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4
CO1	3	2	....	....	2.	....	...	1	3	2	...	2.	1	2	1	3
CO2	3	1	....	....	2	....	2	....	2	....	2	3	2	3	2	2
CO3	1	1	....	....	2	....	2	....	2	1.	2	3.	2	2	3	1
CO4	2	3	....	2	1	....	...	...	2	3	2	2	3	3	2	2
CO5	2	2	....	2	3	2	....	2	3	3	1	2	3	2	3	2
CO6	2	3	....	2	2	2	2	3	1	3	2	2	2	1	1	3

3: Highest Correlated, 2: Medium Correlated, 1: Lowest Correlated

<b>Course code</b>	: MBOC 204			
<b>Course Name</b>	: Plant Breeding and Biostatistics			
<b>Semester /Year</b>	: II			
	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
	3	0	0	3

L - Lecture T – Tutorial P – Practical C – Credit

**Course Objectives: The objectives of this course are**

1. To integrate molecular methods with conventional improvement strategies to accelerate plant breeding.
2. To gain knowledge on commercially important plants, their breeding systems and strategies employed for crop improvement.
3. To have knowledge of analysis of scientific data with the help of bio statistical tools.

**Course contents**

**Unit 1-** The role of plant breeding—historical aspects and genetic basis: mode of reproduction in relation to breeding methods, breeding techniques; method of plant breeding in relation to self-pollinated and cross pollinated plants. (No. of Hours: 8)

**Unit 2-** Self- incompatibility system, male sterility, Selection: Mass selection, Pure line selection, Hybridization: Interspecific and Inter generic; back-cross hybridization.

(No. of Hours: 8)

**Unit 3-** Heterosis: Its genetic and physiological basis. Breeding for resistance to diseases, physiological races. Role of mutation in crop improving and evolution

(No. of Hours: 6)

**Unit 4-** Plant breeding work done in India with special reference to potato, paddy, wheat and sugarcane. Maintenance of collection, registration of varieties, seed production, testing, certification and distribution. (No. of Hours: 9)

**Unit 5-** Bio-statistics and its application in life sciences. Methods of representation of statistical data and measurements of central tendencies. Correlation, regression, curve fitting and ratio of variation. Probability and use of binomial trials. Test of significance, X, 't' and 'F' tests.

(No. of Hours: 14)

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**Course outcomes (COs):****Upon successful completion of the course a student will be able to**

CO1	Recall the knowledge about the fundamental aspects of plant breeding and Biostatistics.
CO2	Understand the experimental steps and methods involved in generating new varieties using classical and contemporary breeding practices
CO3	Explain the maintenance, registration, production, testing, certification and distribution of seeds. Illustrate the methods of plant breeding.
CO4	Analyse the application of plant breeding and statistical methods to conduct research
CO5	Summarized knowledge of plant breeding techniques and formulation of Biostatistics.
CO6	Generalized the all concern area of plant breeding and Biostatistics.

**Suggested Textbooks**

1. Harihar, Ram, 1997. Vegetable Breeding; Principles and Practices. Jagminder Book Agency. New Delhi.
2. Hill, J. 1997. Quantitative and Ecological Aspects of Plant Breeding, Jagminder Book Agency. New Delhi.
3. Kapoor, R.L. 1997. Plant Breeding and Crop Improvement. 2Vols
4. McDonald, M.B. 1997. Seed Production: Principles and Practices.
5. Bliss, C.I. 1967. Statistics in Biology. 2Vols. McGrawHill, NewYork.
6. Downey, N. M and Heath, R.W. 1960. Basic Statistical Methods, Harper International.
7. Rayner, A.A. 1969. Afirst Coursein Biometry for Agriculture Students. Peitermaritzburg. University of Natal Press.
8. Singh, R.K. 1994. Biometrical Techniques in breeding and Genetics. Bishen Singh Mahendra Pal Singh. Dehradun.
9. Watt, T. 1993. Introductory Statistics for Biology Students. Narosa, NewDelhi.

**Reference Books**

1. Poelhman, J.M and Sleeper, D.R.1995.Breeding Field Crops. Panima Publ. House, NewDelhi.
2. Sharma, J.R. 1994. Principles and Practice of Plant Breeding. Tata McGrawHill Publ. Co. Ltd. New Delhi.
3. Singh, B.D. 2002. Plant Breeding Principles and Methods. Kalyani Publ. New Delhi.
4. Winer, B.J. 1962. Statistical Principles in Experimental Design. McGrawHill, NY

**CO-PO Mapping**

Course	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3	PS O4
CO1	2	...	2	3	...	2	1	2	3	3	1	2	2	1	2	...
CO2	2	...	1	2	...	1	2	2	3	....	3	3	2	2	3	2
CO3	2	...	1	3	...	2	1	2	3	....	3	2	1	2	2	3
CO4	3	...	2	1	...	2	1	2	2	3	2	1	3	2	2	3
CO5	2	...	3	1	....	3	2	2	2	...	2	3	2	3	2	2
CO6	2	....	3	2	...	2	2	2	2	2	3	3	2	3	2	3

3: Highest Correlated, 2: Medium Correlated, 1: Lowest Correlated

Course code : MBOL 205

<b>Course Name : Laboratory Course-I</b>				
<b>Semester /Year : I</b>				
	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
	0	0	4	4

L - Lecture T - Tutorial P - Practical C - Credit

### Course contents

1. Effect of gravity, uni lateral light and plant growth regulators on the growth of young seedlings.
2. Role of dark and red light/far red light on the expansion of cotyledons and epicotyl hook opening in pea.
3. Study of cyto-histological zones in the shoot apical meristem (SAM) in sectioned and double stained slides of suitable plants such as *Coleus*, *Kalanchoe*, *Nicotiana*. Examination in shoot apices in a monocot both in T.S. and L.S. to show the origin of leaf primordia.
4. Study of alternate and distichous, alternate and superposed, opposite and superposed opposite and decussate leaf arrangement. Examination of rosette plants (*Launaea*, *Mollugo*, *Raphanus*, *Hyoscyamus*, etc.) and induction of bolting under natural conditions as well as GA treatment.
5. Microscopical examination of vertical section of leaves, such as that of *Cannabis*, *Nicotiana*, *Zea mays* and *Triticum* to understand the internal structure of the tissue and trichomes, glands, etc. Also to study the anatomy of C3 and C4 plants.
6. Study of epidermal peels of leaves to study the development and final structure of stomata and prepare stomatal index. Demonstration of the effect of ABA on stomatal closure.
7. Study the whole roots of dicots and monocots. Examination of root apical meristem and its derivatives (using maize, aerial roots of banyan, etc.). Study of lateral roots. Study of lateral roots with different types of nodules.
8. Study of microsporogenesis and gametogenesis in sections of anthers.
9. Examination of modes of anther dehiscence and collection of pollen grains form icroscopic
10. Examination (maize, grasses, *Cannabis sativa*, *Crotolaria*, *Tradescantia*, *Brassica*, *Petunia*, *Solanum melongena*, and locally available flowers).
11. Tests for pollen-viability using stains and *in vitro* germination. Pollen germination using hanging drop and sitting drop cultures.
12. Pollen storage, pollen-pistil interaction, self-incompatibility, *in-vitro* pollination.
13. Study of ovules in cleared preparations. Study of monosporic, bi-sporic and tetra-sporic types of embryo sac development through permanent slides.
14. Field study of types of flowers with different pollination mechanisms (wind pollination, insect pollination, etc.).
15. Emasculation, bagging and hand pollination techniques to study pollen germination. Study of seed dormancy and methods to break dormancy.
16. The practical course of this section is divided into three units:(1) Laboratory work,(2) Field survey and (3) Scientific visits.
17. Food crops: wheat, rice, maize, chickpea, potato, tapioca, sweet potato, sugarcane; morphology, anatomy and micro chemical tests for stored food materials.
18. Forage/fodder plants: Study of ten important fodder crops of the locality.

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19. Plant fibers: Textiles fibers (cotton, jute, sun hemp, *Cannabis*, *Grewia*, etc.), Cordage fibers (coir), Stuffing fibers (silk cotton). Morphology, anatomy, microscopic study of whole fibers using appropriate, staining procedures.
- Medicinal and aromatic plants including narcotics and antibiotics.
  - Vegetable oils: Mustard, groundnut, soybean, coconut, sunflower and castor. Morphology, microscopic structure of oil yielding tissues, test for oil and iodine number.
  - To prepare a water extract of vegetable tannins (*Acacia*, *Terminalia*, *Camellia*, *Cassia*) and dyes (*Curcuma longa*, *Bixaorellana*, *Indigofera*, *Butea monosperma*, *Lawsonianermis*, etc.).

### Course outcomes (COs):

Upon successful completion of the course a student will be able to

CO1	Recall the effect of gravity, unilateral light and plant growth regulators on the growth of young seedlings.
CO2	Understand the role of dark and red-farred light on the expansion of cotyledons and epicotyls hook opening in pea.
CO3	Develop the cyto histological zones in the shoot apical meristem through preparing sectioned and double stained slides of various suitable plant species, such as <i>Coleus</i> , <i>Kalanchoe</i> and <i>Nicotiana</i> .
CO4	Illustrate the leaf arrangement through studying fresh specimens of various types.
CO5	Analyze the differences in the anatomy of C3 and C4 plants by making suitable preparation of leaves of various plants such as <i>Cannabis</i> , <i>Nicotiana</i> , <i>Zea mays</i> and <i>Triticum</i> .
CO6	Generalized the entire topic related to Plant anatomy, embryology, cytogenetics, resource utilization. Report preparation of Field trips, compilation of field notes, the preparation of museum specimens and/or live potted specimens of taxonomic interest and submission of the excursion report.

### Suggested Textbooks

- Singh, Pande and Jain. (2017). Anatomy and Embryology of Angiosperm. Rastogi Publication.
- Bijan Bihari Dutta. (2015). A Handbook of Plant Resource Utilization and Conservation. Publ. by Authors press.

### Reference Books

- Hussain, A. (2016). Reproductive Biology of Plants. Med Tech.
- Singh, Pande and Jain (2008). Economic Botany. Rastogi Publication

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<b>Course code</b>	: MBOL 206			
<b>Course Name</b>	: Laboratory Course-II			
<b>Semester /Year</b>	: I			
	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
	0	0	4	4

L - Lecture T – Tutorial P – Practical C – Credit

### Course contents

1. Study of mitotic chromosomes in root tips and leaf buds and meiotic chromosomes in floral buds.
2. Isolation of chloroplasts and SDS-PAGE profile of proteins to demarcate the two subunits of Rubisco.
3. Isolation of DNA and preparation of 'cot' curves.
4. Restriction digestion of plant DNA, its separation by agarose gel electrophoresis and visualization by ethidium bromide staining.
5. Isolation of RNA and quantitation by spectro photometric method.
6. Southern blot analysis, Northern blots analysis, Western blotting and ELISA.
7. Genetical problems on Mendelian and post- Mendelian ratios, gene interactions, sex-linked inheritance, chromosomal mapping, etc.
8. Application of common plant breeding techniques.
9. To work out the mode of pollination in a given crop and extent of natural out-crossing
10. Identification of Indian varieties of important crops.
11. Floral biology of local food, pulse, vegetable and horti-cultural crops.
12. Collection of germplasm of different crops being grown in the area.
13. Study of techniques of bio metrical studies.
14. To test the goodness of fit and independent assortment using Chi-square method.

### Course outcomes (COs):

Upon successful completion of the course a student will be able to

<b>CO1</b>	Recall the various stages of mitotic and meiotic cell divisions.
<b>CO2</b>	Estimate the SDS-PAGE of chloroplastic proteins.
<b>CO3</b>	Prepare the restriction digestion of plant DNA and its separation using AGE and visualization by staining with EtBr
<b>CO4</b>	Illustrate southern, northern, western blotting and ELISA.
<b>CO5</b>	Evaluate the problems related to the Mendelian, post-Mendelian ratios, gene interactions, sex linked inheritance and chromosomal mapping.
<b>CO6</b>	Generalized and solve the normal practices of cytogenetics, molecular biology and plant breeding.

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**Suggested Textbooks**

1. Glick, B.R. and Thompson, J.E. 1993. Methods in Plant Molecular Biology and Biotechnology. CRC Press, Boca Raton, Florida.
2. Hackett, P.B., Fuchs, J.A. and Messing, J.W. 1988. An Introduction to Recombinant DNA Techniques: Basic Experiments in Gene Manipulation. The Benjamin/Cummings Publishing Co., Inc Menlo Park, California.

**Reference Books**

1. Shaw, C.H. (Ed.), 1988. Plant Molecular Biology: A Practical Approach. IRL Press, Oxford.
2. Snustad. D.P. and Simmons, M.J. 2000. Principles of Genetics (2<sup>nd</sup>edition). John Willey & Sons Inc., USA.

<b>Course code</b>	: MBOC 301			
<b>Course Name</b>	: Plant Physiology and Biochemistry			
<b>Semester /Year</b>	: III			
	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
	3	0	0	3

L - Lecture T – Tutorial P – Practical C – Credit

**Course Objectives: The objectives of this course are**

1. This course aims to educate student about the mechanism and physiology life processes in plants. It focus on the plant nutrient uptake and translocation, photosynthesis, respiration and nitrogen metabolism.
2. To educate student about the various metabolic pathways lead it to the formation of significant molecules and their catabolism. It focuses upon the vital role of each of these molecules in plants

**Course contents**

**Unit 1.** Concept of water potential, diffusion, osmosis and Imbibition. Energy flow: Principles of thermodynamics, free energy and chemical potential, redox reactions, structure and functions of ATP. Membrane transport and translocation of water and solutes: Plant-water relations; mechanism of water transport through xylem and transport in cells. Absorption and transpiration of water.

(No. of Hours: 8)

**Unit 2.** Biologically important molecules: Carbohydrates, Amino acids, Proteins and Lipids. Fundamentals of enzymology: General aspects of enzymes, allosteric mechanism, regulatory and active sites, isozymes, kinetic analysis.

(No. of Hours: 12)

**Unit 3.** Photo physiology and photosynthesis: General concepts and historical background, evolution of photosynthetic apparatus, photosynthetic pigments and light harvesting complexes, photo oxidation of water, light reaction, Z scheme and photo phosphorylation, mechanism of electron transport, carbon assimilation – the Calvin cycle, photorespiration and its significance, the C4 cycle, the CAM pathway, factors of photosynthesis.

(No. of Hours: 10)

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**Unit 4.** Respiration and lipid metabolism: Overview of plant respiration, Glycolysis, the TCA cycle, electron transport and ATP synthesis, pentose phosphate pathway, Glyoxylate cycle, alternative oxidation system, photorespiration. **(No. of Hours: 8)**

**Unit 5.** Nitrogen fixation, nitrogen and sulphur metabolism: Overview, biological nitrogen fixation, nodule formation and nod factors, mechanism of nitrate uptake and assimilation. (No. of Hours: 4). Phytohormones and Sensory photobiology: History of discovery of phytochromes and cryptochromes, and their photochemical and biochemical properties. **(No. of Hours: 7)**

### Course outcomes (COs):

**Upon successful completion of the course a student will be able to**

CO1	Remember the concept of water potential, diffusion, osmosis and Imbibition, Energy flow, Biomolecules, photosynthesis, and metabolism, nitrogen fixation, translocation, Phytohormones and Sensory photobiology.
CO2	Understand the knowledge of water and translocation in plants with reference to metabolism and respiration.
CO3	Explain structure, composition and functional mechanisms of various biologically important molecules like carbohydrates, amino acids, proteins and lipids, photosynthesis, respiration and Phytohormones.
CO4	Analyze the knowledge about membrane transport and translocation of water and solutes.
CO5	Summarized the fundamentals and advanced aspects of water potential, photosynthesis, respiration and biomolecules metabolism and Phytohormones.
CO6	Create a general idea of plant physiology and biochemistry.

### Suggested Textbooks

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

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**Reference Books**

1. Buchanan, B.B., Gruissem, W. and Jones, R.L. 2000. Biochemistry and Molecular Biology of Plants. American Society of Plant Physiologists, Maryland, USA.
2. Dennis, D.T., Turpin, D.H., Lefebvre, D.D. and Layzell, D.B. (eds) 1997. Plant Metabolism (second edition). Longman, Essex, England.
3. Hopkins, W.G. 1995. Introduction to Plant Physiology. John Wiley & Sons, Inc., New York, USA.
4. V.K. Jain. (2017). Plant Physiology. S. Chand Co. Pvt. Ltd.

**CO-PO Mapping**

Course	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3	PS O4
CO1	3	2	....	....	2.	....	...	1	3	2	...	2.	1	2	1	3
CO2	3	1	....	....	2	....	2	...	2	....	2	3	2	3	2	2
CO3	1	1	....	....	2	....	2	....	2	1.	2	3.	2	2	3	1
CO4	2	3	....	2	1	....	...	...	2	3	2	2	3	3	2	2
CO5	2	2	....	2	3	2	....	2	3	3	1	2	3	2	3	2
CO6	2	3	....	2	2	2	2	3	1	3	2	2	2	1	1	3

3: Highest Correlated, 2: Medium Correlated, 1: Lowest Correlated

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<b>Course code</b>	: MBOC 302			
<b>Course Name</b>	: Ecology and Remote Sensing			
<b>Semester /Year</b>	: III			
	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
	3	0	0	3

L - Lecture T – Tutorial P – Practical C – Credit

**Course Objectives: The objectives of this course are**

1. To provide exposure to students in gaining knowledge on concepts and applications leading to modelling of earth resources management using Remote Sensing.
2. This course aims to introduce the concepts and principles of ecology, biological diversity, conservation, sustainable development, population, community and ecosystem structure and function, application of these concepts to solve environmental problems.

**Course contents**

**Unit 1.** Vegetation organization: Concepts of community and continuum; concept of ecological niche. Vegetation development: Temporal changes (cyclic and non-cyclic); mechanism of ecological succession (relay floristics and initial floristic composition; Facilitation, tolerance and inhibition models); changes in ecosystem properties during succession. **(No. of Hours: 8)**

**Unit 2.** Ecosystem organization: Structure and functions; primary production (methods of measurement, global pattern, controlling factors); energy dynamics (trophic organization, energy flow pathways, ecological efficiencies). (No. of Hours: 6). Global bio geochemical cycles of C, N, P and S; mineral cycle (pathways, processes, budgets) in terrestrial ecosystems. **(No. of Hours: 8)**

**Unit 3.** Ecosystem stability: Concept (resistance and resilience); ecological perturbation (natural and anthropogenic) and their impact on plants and ecosystems; ecology of plant invasion; environmental impact assessment; ecosystem restoration. Biological diversity: Concepts and levels; role of biodiversity in ecosystem functions and stability; speciation and extinction; IUCN categories of threat; distribution in global patterns; terrestrial biodiversity hot spots; inventory.

**(No. of Hours: 9)**

**Unit 4.** Soil: Definition, formation, profile and components and soil types of the world. Climate change: Green house gases (CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O, CFCs; sources, trends and role); Ozone layer and ozone hole; consequences of climate changes (CO<sub>2</sub> fertilization, global warming, sea level rise, UV radiation). Fire as an ecological factor: Types, role of fire, extent and causes of fire in forest,

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grassland sand in tropical savanna, fuel load, controlled burning, fire in different forest types in Uttarakhand; fire as management tool. (No. of Hours: 12)

**Unit 5. Remote Sensing:** Concepts and stages in the acquisition of remote sensing data; Spectral signature, Photographic and non-photographic sensors, Space Platforms. Basics of Global Positioning System, GPS Satellites and GPS utility. Application of remote sensing in ecological and forestry research. (No. of Hours: 8)

### Course outcomes (COs):

Upon successful completion of the course a student will be able to

CO1	Remember the concept of ecology, ecological dynamics and Application of remote sensing. Correlate ecological dynamics and regulation of vital processes on earth as biogeochemical cycles.
CO2	Understand the knowledge of ecology with reference to ecosystem, succession and biogeochemical cycles with the Application of remote sensing.
CO3	Explain ecosystem services, ecological resilience, ecological economics, and landscape ecology, soil profiling climate change and Remote Sensing.
CO4	Explain the concepts of Ecology and Remote Sensing.
CO5	Summarize the forces impacting ecosystems viz., climate change, stress, population, consumerism, globalization, land use change.
CO6	Generalized the fundamentals, and applications of remote sensing in ecological and forestry research.

### Suggested Textbooks

1. Odum, E.P. (2005). Fundamentals of Ecology. New Delhi, India: Cengage Learning India Pvt. Ltd., 5th edition.
2. Kormondy, E.J. (1996). Concepts of Ecology. New Delhi, India: PHI Learning Pvt. Ltd. 4th edition.
3. Sharma, P.D. (2010). Ecology and Environment. Meerut, India: Rastogi Publications. 8th edition
4. Singh, J.S., Singh, S.P., Gupta, S.R. (2014). Ecology, Environmental Science and Conservation. New Delhi, India: S. Chand.
5. Panda, B.C. (2008). Remote Sensing: Principles and Applications. Viva Books.

### Reference Books

1. Ambasht, R.S. and Ambasht, N.K. (2008). A text book of Plant Ecology, CBS Publishers & Distributors PVT. LTD.
2. Majumdar, R and Kashyap, R (2019). Practical Manual of Ecology and Environmental Science, New Delhi, India: Prestige Publishers

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3. Singh, J.S., Singh, S.P., Gupta, S. (2006). Ecology, Environment and Resource Conservation. New Delhi, India: Anamaya Publications.

**CO-PO Mapping**

Course	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3	PS O4
CO1	2	3	....	2	2	....	...	1	2	1	....	3	3	3	....	2.
CO2	3	...	2	3	3	2	2	1	3	2	2	3	1	1.	2	2.
CO3	2	2	2	2	2	....	3	2	2	3	1	2	1	1.	2	3.
CO4	1	3	2	2	2	....	...	1	3	2	2	2	2	3	....	1.
CO5	2	3	2	....	2	....	3	1	3	2	...	1	2	3.	....	3
CO6	3	2	1	2	3	2	2	2	3	2	2	1	3	2	2	3

3: Highest Correlated, 2: Medium Correlated, 1: Lowest Correlated

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<b>Course code</b>	: MBOL 303			
<b>Course Name</b>	: Laboratory Course-I			
<b>Semester /Year</b>	: III			
	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
	0	0	4	4

L - Lecture T – Tutorial P – Practical C – Credit  
**Course contents**

#### Practical Exercises based on MBOC 301

1. To study the effect of temperature upon the permeability of the cytoplasmic membrane.
2. To determine the osmotic pressure (potential) of cells of living cells plasmolytic method
3. To calculate stomatal frequency and stomatal index of green leaves.
4. To set up a Wilmott's bubbler and to study the effect of the following on the rate of photosynthesis  
 (a) Varying CO<sub>2</sub> concentration and (b) different wavelengths of light.
5. To extract the four pigments i.e. chlorophyll a & b, carotene and xanthophylls from the green leaves and preparation of their absorption spectrum.
6. To separate the four pigments i.e. chlorophyll a & b, carotene and xanthophylls from the green leaves by paper chromatography.
7. To separate the amino acids by paper chromatography.
8. Principles of colorimetry, spectro-photometry and flourimetry.

#### Practical Exercises based on MBOC 302

1. To determine the minimum size of the quadrat by species are a curve method and minimum number of quadrats to be laid down in the field understudy.
2. To determine the frequency, density and abundance of each species present in community.
3. To calculate relative frequency and relative density of each species in a given area.
4. To calculate mean basal cover and total basal cover of each species in a given area.
5. To calculate the Alpha diversity, Beta diversity and total diversity of given community.
6. To calculate water holding capacity of three samples of various soil types and to find the percolation percentage of water in the given soil.
7. To test the pH and the buffering properties of soils.
8. Study of types of aerial photos and satellite data products.

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**Course outcomes (COs):****Upon successful completion of the course a student will be able to**

CO1	Recall the knowledge of effect of the permeability of the cytoplasmic membrane, water potential osmosis photosynthesis.
CO2	Observe the Principles of colorimetry, spectro-photometry and fluorimetry.
CO3	Illustrate the separation of chloroplast pigment and amino acids by paper and column chromatography.
CO4	Contrast and execute the minimum size and number of quadrats to be laid down in the field for the calculating the diversity indices.
CO5	Test the pH and the buffering properties of soils.
CO6	Solve the problem related to plant physiology, biochemistry and ecology.

**Suggested Textbooks**

1. Bajracharya, D.1999. Experiments in Plant Physiology: A Laboratory Manual. Narosa Publishing House, New Delhi.
2. Kapoor /Govil. 2000. Experimental Plant Ecology.
3. Krebs, C.J. 1989. Ecological Methodology. Harper and Row, New York, USA.

**Reference Books**

1. Plummer, D.T. 1988. An Introduction to Practical Biochemistry. Tata McGraw-Hill Publishing co. Ltd., New Delhi
2. Misra, R.1968. Ecology WorkBook. Oxford & IBH New Delhi.
3. Moore, P.W. and Chapman, S.B.1986. Methods in Plant Ecology. Black well Scientific Publications.

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<b>Course code</b>	: MBOE 304			
<b>Course Name</b>	: Palynology and Pollination Biology			
<b>Semester /Year</b>	: III			
	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
	3	0	0	3

L - Lecture T – Tutorial P – Practical C – Credit

**Course Objectives: The objectives of this course are**

1. To prepare the students with a good and up-to-date knowledge of the morphology, structure and function of the pollen and spores and the applications of the Pollen Analysis in Taxonomy, Ecology, Geology, Aerobiology, Medicine, etc.

**Course contents**

**Unit 1.** General Introduction, microsporogenesis, micro spore tetrads and polarity of spores and pollen grains. Pollen wall development and pollen chemistry, Chemical nature of sporopollenin, development of pollen wall, Ubisch body, pollen wall proteins, origin and formation exine less pollen grains. Spore-pollen morphology: Symmetry, shape, size, aperture patterns, NPC System for numerical expression of apertural details, exine stratification, surface structures and sculptures of sporoderm. (No. of Hours: 9)

**Unit 2.** A. Palyno-taxonomy: Systematic palynology, identification key and evolutionary trends among pollen grains based on palynotaxonomical works. (No. of Hours: 9)

**Unit 3.** Aeropalynology with reference to allergy: Aeroallergens, introductory idea of Immune System with special reference to IgE. Study of airspora, chemical nature of exine-borne allergens, allergic taxa of North-West Himalaya. (No. of Hours: 9)

**Unit 4.** Melisso-palynology: Indian species of honeybees, importance of pollen grains as constituent of bee-bread, pollen-collecting mechanism of honey bees, analysis of pollen load and honey sample in understanding bee forage, objectives of melisso-palynological studies, and important bee plants of North-West Himalaya. (No. of Hours: 9)

**Unit 5.** Palaeo-palynology: Introductory idea about palaeo-palynological remains, significance of palaeopalynology. Forensic-palynology: Definition and significance, a few well-known case studies. Pollination-Biology: Pollen dispersal units; pollination types, contrivances for cross-and self- pollination; pollen vectors, pollination modes and flora organization, Pollen viability and storage. (No. of Hours: 9)

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**Course outcomes (COs):**

Upon successful completion of the course a student will be able to

CO1	Recite the general concepts of palynology
CO2	Understand the structure and development of pollen wall development.
CO3	Examine the morphological features of Spore-pollen.
CO4	Analyze and identify the various aspects of Palyno-taxonomy.
CO5	Summarized the importance of aeropalynology with reference to allergy.
CO6	Generalized the concepts Palynology and Pollination Biology

**Suggested Textbooks**

1. Erdtman, G. 1952. Pollen morphology and Plant Taxonomy, Angiosperm: Almquist and Wiksell, Stockholm.
2. Bhattacharya, K. and Majumdar, M.R. 2011. A text book of Palynology. p364. New Central Book Agency.

**Reference Book**

1. Nair, P.K.K. 1966. Essentails of Palynology; Asia Publication House Lucknow.
2. Woodhouse, R.P. 1935. Pollen Grains: Hafner Publication Co.

**CO-PO Mapping**

Course	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3	PS O4
CO1	2	3	....	2	2	.....	...	1	2	1	....	3	3	3	....	2.
CO2	3	...	2	3	3	2	2	1	3	2	2	3	1	1.	2	2.
CO3	2	2	2	2	2	.....	3	2	2	3	1	2	1	1.	2	3.
CO4	1	3	2	2	2	.....	...	1	3	2	2	2	2	3	....	1.
CO5	2	3	2	....	2	.....	3	1	3	2	...	1	2	3.	.....	3
CO6	3	2	1	2	3	2	2	2	3	2	2	1	3	2	2	3

3: Highest Correlated, 2: Medium Correlated, 1: Lowest Correlated

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<b>Course code</b>	: MBOE 305			
<b>Course Name</b>	: Fresh water algal flora of Himalaya			
<b>Semester /Year</b>	: III			
	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
	3	0	0	3

L - Lecture T – Tutorial P – Practical C – Credit

**Course Objectives: The objectives of this course are**

To introduce students regarding biological diversity of fresh water algal species representing various groups and distributed in diverse fresh water habitats of Himalaya with special emphasis on Uttarakhand Himalaya, their role, documentation and conservation.

**Course contents**

**Unit 1-** Characters & Keys: Green and Blue-Green Algae: Taxonomy terminology, flora in Himalaya Macrophytic vegetation. Centrale and Pennale diatoms, diatom taxonomy terminology.

(No. of Hours: 8)

**Unit 2-** Centrale diatom Families and Genera Melosira, Cyclotella in Himalaya. Araphid Fam& genera Fragilaria, Diatoma, Meridion, Hannae in Uttarakhand Himalaya.

(No. of Hours: 10)

**Unit 3-** Characters of raphidiod and monoraphidiod families Raphidiod: Eunotia Monoraphids, Achnanthaceae – Achnanthidium, Cocconeis.

(No. of Hours: 9)

**Unit 4-** Characters of naviculoidbiraphid families Naviculoid diatom flora Naviculaceae: Navicula& Cymbellasensulato & sensustricto, Gomphonema Other naviculoid diatom flora: Diploneis, Pinnularia, Caloneis.

(No. of Hours: 8)

**Unit 5-** Characters of non-naviculoidbiraphid families Bacillariaceae Nitzschia, Denticula Epithemiaceae: Epithemia Surirellaceae: Surirella Algal communities in Himalayan lotic, lentic systems, wetlands Ecological preferences of abundant forms of Himalaya (OMNIDIA).

(No. of Hours: 12)

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**Course outcomes (COs):**

Upon successful completion of the course a student will be able to

CO1	Recall the taxonomic keys for identifying different floral diversity in the Himalayan region.
CO2	Understand freshwater diatoms and their taxonomic terminology will be useful and will have a brief insight.
CO3	Examine floral diversity, which plays many important and beneficial roles in freshwater ecosystems of the Himalayan regions.
CO4	Compare characters of Green, blue-green algae and their taxonomic terminology
CO5	Summarized the Fresh water algal flora of Himalayan region.
CO6	Generalized the concept of Fresh water algal flora of Himalaya

**Suggested Textbooks**

1. Fresh water Diatoms of Central Gujarat (with a review and some others). H P Gandhi, Bishen Pal Singh, Mahendra Pal Singh, Dehradun
2. Algal flora of Andaman & Nicobar Prasad & Srivastava
3. Ganga: A water marvel, A.C. Shukla and A. Vandana, Ashish Publishing House, New Delhi

**Reference Books**

1. Bellinger, E.G., Sigeo, D.C. (2010) Freshwater Algae (Identification and Use as Bioindicators). Wiley-Blackwell, pp1-243.
2. Vuuren, V.J.S., Taylor, J., Gerber, A., Van Ginkei, C. (2006). Easy identification of the most common Fresh water Algae. A guide for the identification of microscopic algae in South African Fresh waters, Publ. by North West University, Potchefstroom, p212.

**CO-PO Mapping**

Course	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3	PS O4
CO1	2	1	2	2	...	...	1	3	2	...	3	2	3	3	1	2
CO2	3	2	2	2	...	...	...	2	1	2	1	3	3	3	1	2
CO3	2	1	2	2	2	...	2	...	3	2	2	1	1	2	2	3
CO4	2	1	3	2	1	3	...	...	3	2	...	3	2	2	3	...
CO5	2	1	1	2	3	...	2	2	2	3	2	2	2	1	2	3
CO6	3	2	2	2	1	3	1	1	3	2	...	...	2	3	2	2

3: Highest Correlated, 2: Medium Correlated, 1: Lowest Correlated

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<b>Course code</b>	: MBOE 306			
<b>Course Name</b>	: Plant Health Management			
<b>Semester /Year</b>	: III			
	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
	3	0	0	3

L - Lecture T – Tutorial P – Practical C – Credit

**Course Objectives: The objectives of this course are**

1. To introduce students and develops their skills in biology, ecology and management of a variety of pests in agricultural, horticultural and viticulture ecosystems, especially arthropods, plant pathogens and weeds.
2. The key concepts of the course are integrated, and students enhance their ability to apply them to novel situations in problem-solving sessions.

**Course contents**

**Unit 1.** Basic procedure in diagnosis of plant diseases: Significance of plant diseases.

(No. of Hours: 9)

**Unit 2.** Seed Pathology: Seed borne fungi. Disease transmitted through seeds. Bio deterioration of seed storage. Control of seed borne fungi.

(No. of Hours: 9)

**Unit 3.** Nursery disease: Important disease of nursery plants. Plantation disease: Plantation disease of Chir pine, Eucalyptus, Sal, Teak, Shisam, Populus, Acacia (Catechu).

(No. of Hours: 9)

**Unit 4.** Important disease of cash crops: Sugarcane, Potato and Ginger. How plants defend themselves against pathogen. Control of crop and forest disease. Treatment of wounds. Introduction and various forms of Mycorrhiza. Role of Mycorrhiza in Forestry.

(No. of Hours: 12)

**Unit 5.** Diseases of cereals, millets, vegetables and fruit trees.

(No. of Hours: 6)

**Course outcomes (COs):**

**Upon successful completion of the course a student will be able to**

<b>CO1</b>	Remember the terms associated with plant health management and basic procedure of diagnosis and significance of plant diseases.
<b>CO2</b>	Understand and Learn the concepts of seed pathology and Defence mechanism

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	in plants.
CO3	Illustrate the important of plant diseases with reference to Nursery, cash crops.
CO4	Explain the important diseases of plantation.
CO5	Summarized the various types of Mycorrhizal associations and their role in forestry.
CO6	Generalize and write the diseases of cereals, millets, vegetables and fruit trees.

### Suggested Textbooks

1. Bilgrami, K.S. 1985. Text Book of Modern Plant Pathology. Bishen Singh Mahendra Pal Singh Dehradun.
2. Butler, E.J.1973. Fungi and Disease in Plants, Intern, Book Distributers. Dehradun.
3. Singh, R.S.1983. Plants Diseases. Oxford and IBH Publ. Co. New Delhi.
4. Singh, R.S. Principle of Plants Pathology. Oxford and IBH Publ. Co. New Delhi

### Reference Books

1. Strobel, G.A. and D.E., Mathre 1970. Outlines of Plant Pathology. Van Nostr and Reinhold Co. New York.
2. Tarr, S.A.J.1972.The Principle of Plants Pathology. Winchester Press, New York.
3. Western, J.H. 1971. Diseases of Crop Plants. Mc Millan Press London

### CO-PO Mapping

Course	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3	PS O4
CO1	3	...	2.	2	2	2	...	1	3	2	...	.....	3	2	3	2
CO2	1	3	2	2	1	2	2	2	3	2	3	3	2	2	2	3.
CO3	3	2	2	3	2	2	3	2	3	1	3	2	2	2.	2	2
CO4	2	1	2	2	2	...	1	3	2	3	2	.....	3	2	1	3
CO5	1	3	2	1	1	3	2	3	2	1	2	3	2	2	2	2.
CO6	3	3	2	3	1	2	2	2	...	3	2	3	2	3	3	2

3: Highest Correlated, 2: Medium Correlated, 1: Lowest Correlated

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<b>Course code</b>	: MBOE 307			
<b>Course Name</b>	: Environment Microbiology			
<b>Semester /Year</b>	: III			
	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
	3	0	0	3

L - Lecture T – Tutorial P – Practical C – Credit

**Course Objectives: The objectives of this course are**

1. Understand the role of microorganisms as agents of environmental change.
2. Recognize microorganisms as indicators of alteration of an ecosystem.
3. Understand microbial processes aimed to solve environmental problems.

**Course contents**

**Unit 1:** Fundamentals of Microbial Ecology Ecosystem; Biotic and abiotic components; Habitat and Niche; Population and guilds; Concept of community; Stability hypothesis; Intermediate-disturbance hypothesis; Concept of ecological niche; Ecosystem organization: Structure and functions, Primary production, Energy dynamics (Trophic organization and energy flow pathways).  
(No. of Hours: 9)

**Unit 2:** Air and Aquatic Microbiology: Droplet nuclei, Aerosol, Assessment of air quality, Solid and liquid impingement methods, Brief account of air born transmission of microbes; Aquatic microbiology: Zonation and microbiota of fresh water (Ponds, lake and rivers) and marine habitats (Estuaries and deep sea), Upwelling and down welling, Eutrophication, Microbial assessment of water quality, Water purification.  
(No. of Hours: 9)

**Unit 3:** Microbial Interactions, Positive and negative interactions amongst microbial populations: Cooperation, Neutralism, Commensalism, Synergism, Mutualism, Competition, Amensalism, Parasitism, Predation; Interactions between microorganisms and plants: Rhizobacteria, Mycorrhiza, Epiphytic and endophytic microorganisms; Interactions between microorganisms and animals: Predation on microorganisms by animals, Cultivation of microorganisms by animals for food and food processing.  
(No. of Hours: 9)

**Unit 4:** Air pollution and its control; Sources, Major pollutants, Adverse effect on living organisms (Acid rain and its impact on ecosystem, greenhouse effect, global warming, ozone layer depletion and its effect, smog), Control through; Water pollution and its control: Sources, Ground water contamination, Wastes: Characterization of solid and liquid wastes, Solid waste treatment

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(Landfills, incineration, composting, anaerobic digestion and pyrolysis), Waste water treatment (Pre treatment, primary, secondary and tertiary treatment, Application of biofilm in waste water treatment); Environment impact assessment. (No. of Hours: 9)

**Unit 5:** Impact of Microbes on Environment; Biodegradation of recalcitrant compounds: Pesticides and Petroleum; Bioremediation: In situ and Ex situ remediation, Bioremediation of oil spills; Bioaugmentation; Biomagnifications; Biomineralization; Metal corrosion: Mode of deterioration, Microorganisms involved, Mode of prevention, Microbial plastics; Biodiesel.

(No. of Hours: 9)

### Course outcomes (COs):

Upon successful completion of the course a student will be able to

CO1	Remember the knowledge of Fundamentals of Microbial Ecology, Air and Aquatic Microbiology, Microbial Interactions, Pollution and Impact of Microbes on Environment
CO2	Understand the metabolic processes of microorganisms, principally bacteria, to industrial processes related to the environment.
CO3	Explain the Microbial Ecology.
CO4	Analyse design experiments and interpret results.
CO5	Summarized and use the properties of microorganisms, principally bacteria, to remedy problems of contamination and other environmental impacts.
CO6	Generalized the knowledge of Microbial Ecology.

### Suggested Textbook

- Alexander, M. Microbial ecology. John Wiley and Sons, New York.
- Eldowney, S., and Waites, S. Pollution: Ecology and bio treatment. Longman, Harlow.

### Reference Book

- Baker, K.H. and Herson, D.S. Bioremediation. McGraw- Hill, New York.
- Marshal, K.C. Advances of microbial ecology. Plenum Press, New York.

### CO-PO Mapping

Course	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3	PS O4
CO1	1	2	3	3	2	1	2	...	2	3	2	1	1	3	2	1
CO2	1	3	2	2	1	2	2	2	3	2	3	3	2	2	3	2
CO3	3	2	2	3	2	2	3	2	3	1	3	2	2	2	3	3
CO4	3	3	2	2	2	...	1	3	2	3	2	....	3	3	2	2
CO5	1	2	2	1	1	3	2	3	2	1	1	2	2	2	3	1
CO6	2	2	2	3	1	2	2	2	...	3	1	3	2	3	1	2

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3: Highest Correlated, 2: Medium Correlated, 1: Lowest Correlated

<b>Course code</b>	: MBOL 308			
<b>Course Name</b>	: Laboratory Course-II			
<b>Semester /Year</b>	: III			
	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
	0	0	4	4

L - Lecture T – Tutorial P – Practical C – Credit

**Course contents**

1. Pollen morphological studies of some Pteridophyte, gymnosperms, and angiosperms representing different morphological types using acetolysis/alkali maceration method.
2. Study of in vivo and in vitro germination of pollen grains.
3. Morpho-anatomical study of stigma and style.
4. Study of allergy producing pollen morpho-types
5. Collection and identification of different floral diversity in the Himalayan region.
6. Cultivation of algae of commercial importance.
7. Study of representative genera of different families viz., *Melosira*, *Cyclotella*, *Fragilaria*, *Diatoma*, *Meridion*, *Achnanthydium*, *Cocconeis*, *Navicula* & *Cymbella*, *Gomphonema*, *Diploneis*, *Pinnularia*, *Caloneis*, *Nitzschia*, *Denticula*, Green and Blue-Green Algae.
8. Study of seed borne pathogen. Description of pathogen, symptoms and section cutting.
9. Isolation of some important pathogens.
10. Procedure of equipments uses.
11. To establish a plant disease clinic in the department for advise to local people.
12. Sampling and enumeration techniques for microbes.
13. Determination of total microbial count in a water sample.
14. Determination of total count (MPN) of coliform in a water sample.
15. To prepare the Nutrient Agar/CDA/MEA medium for culturing bacteria and Fungi present in our surroundings.
16. Isolation of Fungi/bacteria by the Pour- plate method, Spread-pate and Streak Plate method.
17. To prepare the differential medium (MacConky) so as to grow the enteric bacteria.
18. Isolation of fungi from the given sample of water and soil.
19. Isolation of the *Lactobacillus* bacteria from the given sample of curd.
20. Working principle molecular technique-PCR

**Course outcomes (COs):****Upon successful completion of the course a student will be able to**

<b>CO1</b>	Examine the pollen grains from honey samples and to study the frequency of different Morpho-types.
<b>CO2</b>	Distinguish the in vivo and in vitro germination of pollen grains.
<b>CO3</b>	Develop the Cultivation of algae of commercial importance
<b>CO4</b>	Analyse and Isolate some important plant pathogen.
<b>CO5</b>	Evaluate and Isolation of Fungi/bacteria by the Pour- plate method, Spread-pate and Streak Plate method.
<b>CO6</b>	Solve the problem related pollen morphology and ecology.

**Suggested Textbooks**

1. Hurst, Crawford, Garland, Lipson, Mills & Stetzenbach. 2007. Manual of environmental microbiology. 3th Edition. ASM Press.
2. Husain Hadi Khan et al. 2019. Practical Lab manual for microbiology and plant pathology, Akinik Publication, Delhi.
3. James, B. Riding. 2021. A guide to preparation protocols in palynology. Taylor and Francis.

<b>Course code</b>	: MBOS 309			
<b>Course Name</b>	: Forest Ecology			
<b>Semester /Year</b>	: III			
	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
	3	0	0	3

L - Lecture T - Tutorial P - Practical C - Credit

**Course Objectives: The objectives of this course are**

1. This course will provide students and land managers with basic forest ecology and management knowledge and skills in order to better apply them in various decision making situations, including habitat conservation, forest planning, and Service guidance.
2. The skill set gained by students will help them improve communications with professional foresters, private landowners, federal agency partners, and forest researchers.
3. The course will provide a greater understanding of how silviculture can be used to achieve a range of conservation objectives, including habitat management and ecosystem restoration.

**Course contents**

**Unit 1:** Forests, forestry and man: Definition, forests in geological ages, forests in prehistoric era, shifting cultivation, forests in historical time, scientific forestry, forest policy, natural forest policy, private forest policy, planned forest development, forestry education in India. Essential elements of forest ecology: Extent and boundaries, physical features, geology, river system, soil, land-use pattern, role in country's economy, forests and wild lands.  
(No. of Hours: 12)

**Unit 2:** Forests and trees: Locality factors of the forests, forest influences, forest composition, stand structure, dynamics and growth, classification, forest types and their distribution, species diversity.  
(No. of Hours: 7)

**Unit 3:** Wild Life: Species and distribution, Sanctuaries, Biosphere reserves, wildlife and recreation. Forest conservancy and Potential Productivity: Soil, Water relation and nutrition, soil erosion and conservation, potential productivity of forests, site quality evaluation.  
(No. of Hours: 9)

**Unit 4:** Forest Conservation and Management: i) Impact of deforestation on soil and water, Role of fire: type, extent and cause of fire, fuel load, fire and different forest types of Himalaya. ii) Forest resource management and forest resource information system. iii) Forest cover in India-State of Art, Ground inventory.  
(No. of Hours: 9)

**Unit 5:** Application of Remote Sensing and Geographic Information System (GIS) in Land cover mapping. Vegetation and forest type maps. Environmental Impact Assessment:

Maintenance and conservational policies such as Joint Forest Management (JFM) and Agro forestry in the region.

(No. of Hours: 8)

### Course outcomes (COs):

Upon successful completion of the course a student will be able to

CO1	Describe the relationship of forests, forestry and man.
CO2	Understand the essential elements of forest ecology.
CO3	Apply the Comprehend the composition, structure, dynamics, growth and classification of forests and also about the factors affecting forests.
CO4	Explain about the various aspects of Wild Life in relation to Sanctuaries and Biosphere reserves.
CO5	Examine the essential components of forest conservancy and its potential productivity.
CO6	Generalized the term forestry.

### Suggested Textbooks

1. Bir, S.S. and Chatha, G.S. 1988. Forest Vegetation Characteristics of Indian Hills. Today and Tomorrows Printers & Publ., New Delhi.
2. Dwivedi, A.P. Forestry in India. Jugal Kishor and Company, Dehradun.
3. Misra, R. Ecology Work Book. Oxford & IBH Publishing Co. New Delhi.
4. Mishra, R. and Gopal, B. Recent Advances in Tropical Ecology: Part I&II. International Society for Tropical ecology, Varanasi.
5. Negi, S.S. 1983. Forest Ecology. Bishen Singh Mahendra Pal Singh, Dehradun.
6. Puri, G.S., Gupta, R.K., Meher- Homji, V.M. and Puri, S. 1989. Forest Ecology: Plant Form, Diversity, Communities and Succession. Oxford and IBH Publishing Co. Pvt. Ltd. New Delhi.
7. Puri, G.S., Meheromji, V.M., Gupta, R.K. and Puri, S. Forest Ecology: Vol I & II. Oxford and IBH Publishing Co. Pvt. Ltd. New Delhi.
8. Singh, G. 1987. Forest Ecology of India. Rawat Publications, Jaipur.

### Reference Books

1. Singh, J.S. and Singh, S.P. 1992. Forests of Himalaya. Consul Book Depot. Gyanodaya Prakashan, Nainital. India.
2. Singh, J.S. Singh, S.P. and Gupta, S.R. 2005. Ecology, Environment and Resource Conservation. Anamaya Publ., F-154/2 Ladosarai, New Delhi-110030
3. Singh, M.P. and Vishwakarma, V. 1997. Forest Environment and Biodiversity. Daya Publ. House, Delhi.
4. Wareing, R.H. and Schlesinger, W.H. 1985. Forest Ecosystems: Concepts and Management. Academic Press, New York.

### CO-PO Mapping

Course	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3	PS O4
CO1	3	...	2.	2	2	2	...	1	3	2	...	.....	3	2	3	2
CO2	1	3	2	2	1	2	2	2	3	2	3	3	2	2	2	3.
CO3	3	2	2	3	2	2	3	2	3	1	3	2	2	2.	2	2
CO4	2	1	2	2	2	...	1	3	2	3	2	.....	3	2	1	3
CO5	1	3	2	1	1	3	2	3	2	1	2	3	2	2	2	2.
CO6	3	3	2	3	1	2	2	2	...	3	2	3	2	3	3	2

3: Highest Correlated, 2: Medium Correlated, 1: Lowest Correlated

<b>Course code</b>	: MBOS 310			
<b>Course Name</b>	: Introduction to Medicinal and Aromatic Plants			
<b>Semester /Year</b>	: III			
	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
	3	0	0	3

L - Lecture T – Tutorial-P – Practical C – Credit

**Course Objectives: The objectives of this course are**

This Course provides introductory information in the production, processing, and marketing of medicinal and aromatic plants on the prairies. It also provides foundational information in the development of an herb enterprise.

**Course contents**

**Unit 1:** MAPs: definition, history, importance and future prospects. Medicinal Plants – past and present status in world and India. MAPs as industrial crops - constraints and remedial measures. Medicinal plant diversity & local healthcare. Medicinal plant conservation – issues and approaches. Medicinal plant conservation areas (MPCA), Non-timber forest products (NTFP), Good Agriculture Practices (GAP). Indian Himalayan region (IHR).

(No. of Hours: 12)

**Unit 2:** Promotion of medicinal plant sector at national level: National Medicinal Plant Board and State Medicinal Plant Boards - objectives and functions. Other organizational initiatives for promotion of MAPs at National and International levels. Demand and supply of medicinal plants. Herbal industries.

(No. of Hours: 8)

**Unit 3:** Important medicinal plants of India with their systematics, geographical distribution and uses. *Acorus calamus*, *Adhatoda vasica*, *Abrus precatorius* *Aloe vera*, *Phyllanthus amarus*, *Stevia rebaudiana*, *Belladonna* and *Cinchona*.

(No. of Hours: 8)

**Unit 4:** Important aromatic plants of India with their systematics, geographical distribution and uses. Introduction and historical background of aromatic plants. Aromatic and cosmetic products.

(No. of Hours: 5)

**Unit 5:** Raw material for perfumes etc. Cosmetic Industries. Major, minor and less known aromatic plants of India. Taxonomic descriptions and uses of important aromatic plants – citronella, davana, damask rose, geranium, khus grass, large cardamom, lavender, lemon grass, mentha, holy basil, patchouli, rosemary Palmarosa, vetiver, artemisia, eucalyptus, thyme, marjoram and oreganum. Aromatic spices - clove, cinnamon, nutmeg, ajwain, dill, celery, tamarind, garcinia, curry leaf and saffron.

(No. of Hours: 12)

**Course outcomes (COs):**

Upon successful completion of the course a student will be able to

CO1	Remember the Knowledge of medicinal and aromatic plants, their importance, and status and future prospects.
CO2	Understand the Good Agriculture Practices and Good Manufacturing Practices
CO3	Practice and conserve the medicinally important herbs
CO4	Explain aromatic plants used in different industries particularly Perfume industry.
CO5	Justify the role of agencies constituted for promotion of medicinal plant sector at national level.
CO6	Adapt the benefits of Medicinal and Aromatic Plants.

**Suggested Textbooks**

1. Medicinal Plants of Uttarakhand by C.P. Kala (2010).
2. Indian Medicinal Plants by P.C. Trivedi (2009).
3. Medicinal Plants of Indian Himalaya by S.S. Samant and U. Dhar

**Reference Books**

1. Hand Book of Aromatic Plants by S.K. Bhattacharjee (2004).
2. Handbook of MAPs by S.K. Bhattacharjee (2009).

**CO-PO Mapping**

Course	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3	PS O4
CO1	1	2	3	3	2	1	2	...	2	3	2	1	1	3	2	1
CO2	1	3	2	2	1	2	2	2	3	2	3	3	2	2	3	2
CO3	3	2	2	3	2	2	3	2	3	1	3	2	2	2	3	2
CO4	3	3	2	2	2	...	1	3	2	3	2	.....	3	3	2	2
CO5	1	2	2	1	1	3	2	3	2	1	1	2	2	2	3	1
CO6	2	2	2	3	1	2	2	2	...	3	1	3	2	3	1	2

3: Highest Correlated, 2: Medium Correlated, 1: Lowest Correlated

<b>Course code</b>	: MBOS 311			
<b>Course Name</b>	: Pathogens and Pests of Crop Plants			
<b>Semester /Year</b>	: III			
	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
	3	0	0	3

L - Lecture T – Tutorial P – Practical C – Credit

**Course Objectives: The objectives of this course are**

1. This course aims to enhance understanding of students in basic concepts of mycology and importance of fungi, as well as develop skills for handling fungi.
2. The course deals with basic concepts in plant pathology and interaction of plants with herbivores. Introduction to agricultural pathogens and pests of national importance will be accompanied by basic concepts in integrated disease/pest management, and breeding plants for durable resistance against insect pests and pathogens

**Course contents**

**Unit 1:** Overview of Fungi and fungus-like organisms (Myxomycetes, Acrasiomycetes, and Oomycetes), A higher-level phylogenetic classification of the Fungi. (No. of Hours: 6)

**Unit 2:** True fungi: Characteristics and important Genera of Phyla – Chytridiomycota, Zygomycota, Glomeromycota, Ascomycota, and Basidiomycota. (No. of Hours: 6)

**Unit 3:** Physiology of fungal growth, reproduction (asexual and sexual), and mating compatibility, Importance and ecological role of fungi. (No. of Hours: 9)

**Unit 4:** Plant Pathology: General concepts, General characteristics of plant pathogenic organisms and pests. Molecular approaches for the investigation of plant diseases. Control mechanisms based on chemical treatments, biological control and genetic engineering. (No. of Hours: 9)

**Unit 5:** Plant interactions with pathogens and pests: Plant-virus interactions with emphasis on poty viruses and horticultural crops; Plant-bacterial interactions with emphasis on Erwinia sp. and potatoes; Plant-fungus interactions with emphasis on Magnaporthe sp. and rice; Plant-nematode interactions with emphasis on Meloidogyne sp. and tomato; Plant-Insect interactions with emphasis on Pieris sp. and crucifers. (No. of Hours: 15)

**Course outcomes (COs):**

Upon successful completion of the course a student will be able to

<b>CO1</b>	Remember the basic fungal biology, taxonomy of the fungi and major fungal lineages
<b>CO2</b>	Understand the skills necessary to isolate and handle fungi from nature, and to discern important microscopic characteristics of fungi.

<b>CO3</b>	Develop functional knowledge on differentiating disease caused by virus, fungi, and bacteria
<b>CO4</b>	Analyze the biology of major, and emerging pathogens and pests of crop plants
<b>CO5</b>	Summarized the advantages and disadvantages of current control practices based on chemical ecology, genetics of plant resistance and breeding including transgenic approaches
<b>CO6</b>	Combine theoretical and practical knowledge of plant disease and pest management

**Suggested Textbooks**

1. Alexopoulos, C.J., Mims, C.W. and Blacwell, M. (2007). Introductory Mycology. Fourth Edition Wiley India Pvt. Limited
2. Webster, J. and Weber, R. (2007). Introduction to Fungi. Third Edition. Cambridge University Press. Cambridge and New York
3. Sethi, I.K. and Walia, S.K. (2018). Text book of Fungi & Their Allies, Second Edition. MacMillan Publishers Pvt. Ltd., Delhi, India
4. Dickinson, M. (2003). Molecular Plant Pathology, Bios Scientific Publishers, London.
5. Sharma, P.D. (2017). Mycology and Phytopathology. Rastogi Publishers, Meerut, India

**Reference Books**

1. Burchett, S. and Burchett, S. (2018). Plant Pathology, Garland Science, US.
2. Koul, O., Dhaliwal, G.S. and Cuperus, G.W. (2004). Integrated Pest Management: Potential, constraints and challenges, CABI Press, UK
3. Dhaliwal, G.S. and Arora, R. (1996). Principles of insect pest management, National Agricultural Technological Information Center, Ludhiana, India

**CO-PO Mapping**

Course	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3	PS O4
CO1	2	1	1	1	3	2	1	2	2	3	2	1	2	3	2	3
CO2	1	2	2	1	2	1	1	3	3	2	3	3	3	2	2	1
CO3	2	1	1	1	1	3	1	2	3	1	3	2	...	3	3	2
CO4	1	1	2	1	2	1	2	3	2	3	2	.....	3	1	1	3
CO5	2	1	2	1	1	3	2	1	2	1	1	2	2	...	1	2
CO6	3	2	3	1	2	3	2	2	...	3	1	3	2	2	3	2

3: Highest Correlated, 2: Medium Correlated, 1: Lowest Correlated

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<b>Course code</b>	: MBOC 401			
<b>Course Name</b>	: Conservation Biology			
<b>Semester /Year</b>	: IV			
	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
	3	0	0	3

L - Lecture T – Tutorial P – Practical C – Credit

**Course Objectives: The objectives of this course are**

1. Systematically understand biodiversity and its vital role in ecosystem function.
2. Identify the importance of biodiversity in natural environments. Critically examine biodiversity and human linkages, and help policy formulating for conservation. Application of knowledge in general communication for public extension.
3. Developing critical thinking for the conservation of biodiversity and strategies used for the conservation of plant diversity, for shaping strategies viz. scientific, social, economic and legal issues; for environmental protection and conservation of biodiversity, social equity and sustainable development.

**Course contents**

**Unit 1:** Conservation: The basic concept, History of conservation biology. Patterns of biodiversity: Global and regional patterns of biodiversity, Distribution, Gradients, Magnitude of biodiversity, Hotspots, keystone species. Uses of biodiversity: food, fodder, timber, fibre, medicine, etc.; biodiversity based products and industries; wild relatives of cultivated plants; scientific role of biodiversity. Threats to biodiversity: Habitat loss and fragmentation, Genetic drift, Inbreeding, Disturbance, Pollution, Climate Change, Overexploitation, Invasive Species, Disease.  
(No. of Hours: 12)

**Unit 2:** Global environmental problems: Global warming, ozone depletion, desertification. Extinction to species: Susceptibility to extinction causes of species extinction, endangered species, Red and Green Data Books. Environmental Impact Assessment (EIA) origin and development, development in India, Purpose and aims of EIA, Core values and principles, EIA process, components of EIA, Participants in EIA process, Impact identification methods.  
(No. of Hours: 8)

**Unit 3:** Conservation of Biological diversity: Genetic principles in conservation, biodiversity assessment and inventory. Survey and monitoring of biological resources: sampling population for biological conservation; Collection and analysis of inventory data, criteria on choice of species for conservation. People participation, biodiversity registers and their maintenance

(No. of Hours: 8)

**Unit 4:** Conservation of energy resources; conservation and maintenance of non-renewable fossil fuel resources; Conservation of biodiversity based renewable energy resources. Conservation of biological resources: In situ and Ex Situ Conservation Strategies, Designing Networks of Protected Areas; Restoration of endangered species. Protected Area Network, PAN with special reference to Uttarakhand and India.

(No. of Hours: 8)

**Unit 5:** Biodiversity and its conservation: International efforts for conserving biodiversity viz., CITES, CBD, IUCN, MAB, UNEP, UPOV (Union for the Protection of New Plant Varieties), WTO etc.). International treaty on Plant Genetic Resources, Wetland conservation, National Forest Policy 1929, Wildlife (Protection) act 1975, Forest (Conservation) Act 1980, Environment (Protection) Act 1986, Fisheries Act 1987, Wildlife (Protection) Amendment Act 1991, Biodiversity Act 2003, etc.

(No. of Hours: 9)

**Course outcomes (COs):**

Upon successful completion of the course a student will be able to

CO1	Remember the Knowledge of basic concepts and history of conservation biology.
CO2	Understand and Learn origin and evolution of organism; genetic plasticity and the invasion of unoccupied ecological niches and conservation strategies of biological resources.
CO3	Apply and Correlate global and regional patterns of biodiversity. Explain PAN and its conservation.
CO4	Explain about the Global environmental problems: Global warming, ozone depletion, desertification.
CO5	Summarized the concept of species extinction, endangered species, Red and Green Data Books.
CO6	Develop the Plan of Environmental Impact Assessment (EIA).

**Suggested Textbooks**

1. Cain, M.L., Bowman, W.D. & Hacker, S.D. 2008. Ecology. Sinauer Associates, Inc.
2. Dhar, U. 1993 (Ed.). Himalayan Biodiversity: Conservation Strategies, Gyanodaya Prakashan, Nainital.
3. Groombridge, B. and Jenkins, M.D. 2000. Global Biodiversity. Earth's living resources in the 21st century, UK. World conservation Monitoring Center. Pp 246.
4. Hunter, M.L.J. 1990. Wildlife, forest and forestry: Principals of Managing forests for biological diversity. Prentice Hall. Englewood. Cliffs. New Jersey. 370pp.
5. Hunter, Jr, M.L. & Gibbs, J.P. 2006. Fundamentals of Conservation Biology. Wiley Blackwell.

**Reference Books**

1. Pullin, A Conservation Biology. Cambridge University Press, the Edinberg Building, Cambridge CB22RU, UK.
2. Primack, R.B. 2006. Essentials of Conservation Biology. Sinauer Associates, Inc.
3. Primack, R.B. 2008. A Primer of Conservation Biology. Sinauer Associates, Inc.

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4. Singh, J.S., Singh, S.P. & Gupta, S.R. 2007. Ecology, Environment and Resource Conservation. Anamaya Publishers, New Delhi.
5. Western, D. and Pearl, M.C. 1989. Conservation for twenty-first century. Oxford University Press, Oxford UK. Pp109-120.

**CO-PO Mapping**

Course	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3	PS O4
CO1	2	1	1	1	3	2	1	2	2	3	2	1	2	3	2	3
CO2	1	2	2	1	2	1	1	3	3	2	3	3	3	2	2	1
CO3	2	1	1	1	1	3	1	2	3	1	3	2	...	3	3	2
CO4	1	1	2	1	2	1	2	3	2	3	2	.....	3	1	1	3
CO5	2	1	2	1	1	3	2	1	2	1	1	2	2	...	1	2
CO6	3	2	3	1	2	3	2	2	...	3	1	3	2	2	3	2

3: Highest Correlated, 2: Medium Correlated, 1: Lowest Correlated

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<b>Course code</b>	: MBOC 402			
<b>Course Name</b>	: Biotechnology and Genetic Engineering of Plants and Microbes			
<b>Semester /Year</b>	: IV			
	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
	3	0	0	3

L - Lecture T - Tutorial P - Practical C - Credit

**Course Objectives: The objectives of this course are**

This course would provide students with an understanding of principles and techniques of plant tissue culture, concepts and methods associated with development and analysis of transgenic plants, and their applications in basic and applied research

**Course contents**

**Unit 1:** Biotechnology: Basic concepts, principles and scope. Plant cell and tissue culture: General introduction, history, scope, concept of cellular differentiation, totipotency.

(No. of Hours: 6)

**Unit 2:** Organogenesis and adventives embryogenesis: Fundamental aspects of morphogenesis, somatic embryogenesis and Androgenesis, mechanisms, techniques and utility. Somatic hybridization: Protoplast isolation, fusion and culture, hybrid selection and regeneration, possibilities, achievements and limitations of protoplast research. (No. of Hours: 10)

**Unit 3:** Applications of plant tissue culture: clonal propagation, artificial seed, production of hybrids and soma clones, production of secondary metabolites/natural products, cryopreservation and germplasm preservation.

(No. of Hours: 8)

**Unit 4:** Recombinant DNA technology: Gene cloning principles and techniques, construction of genomic and cDNA libraries, choice of vectors, DNA synthesis and sequencing, polymerase chain reaction, DNA fingerprinting.

(No. of Hours: 10)

**Unit 5:** Genetic engineering of plants: Aims, strategies for development of transgenic (with suitable examples), Agrobacterium- the natural genetic engineer, T-DNA and transposons mediated gene- tagging. Microbial genetic manipulation: Bacterial transformation, selection of recombinants and transformants, genetic improvement of industrial microbes and nitrogen fixers, fermentation technology.

(No. of Hours: 11)

**Course outcomes (COs):**

Upon successful completion of the course a student will be able to

<b>CO1</b>	Remember the basic concepts, principles and scope of Biotechnology.
<b>CO2</b>	Understand the general introduction, history, scope and concept of plant cell and tissue culture with Recombinant DNA technology.
<b>CO3</b>	Explain the fundamental aspects of organogenesis and adventive

	embryogenesis
<b>CO4</b>	Analyze the concepts, key features and limitations of somatic hybridization technique and Recombinant DNA techniques.
<b>CO5</b>	Summarized the applications of Recombinant DNA technology and plant tissue culture.
<b>CO6</b>	Create the fundamentals of Biotechnology with reference to microbes and plants.

### Suggested Textbooks

1. Bhojwani, S.S. and Razdan, M.K. 1996. Plant Tissue Culture: Theory and Practice (a revised edition). Elsevier Science Publishers, New York, USA.
2. Bhojwani, S.S. 1990. Plant Tissue Culture: Applications and Limitations. Elsevier Science Publishers, New York, USA.
3. Shantharam, S. and Montgomery, J.F. 1999. Biotechnology, Biosafety & Biodiversity. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi.

### Reference Books

1. Vasil, I.K. and Thorpe, T.A. 1994, Plant Cell and Tissue Culture. Kluwer Academic Publishers, the Netherlands.
2. Dubey, R.C. 2018. Biotechnology. S. Chand Publ. Co. Pvt. Ltd., New Delhi.

### CO-PO Mapping

Course	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3	PS O4
<b>CO1</b>	2	3	....	2	2	....	...	1	2	1	....	3	3	3	....	2.
<b>CO2</b>	3	...	2	3	3	2	2	1	3	2	2	3	1	1.	2	2.
<b>CO3</b>	2	2	2	2	2	....	3	2	2	3	1	2	1	1.	2	3.
<b>CO4</b>	1	3	2	2	2	....	...	1	3	2	2	2	2	3	....	1.
<b>CO5</b>	2	3	2	....	2	....	3	1	3	2	...	1	2	3.	....	3
<b>CO6</b>	3	2	1	2	3	2	2	2	3	2	2	1	3	2	2	3

3: Highest Correlated, 2: Medium Correlated, 1: Lowest Correlated

<b>Course code</b>	: MBOL 403			
<b>Course Name</b>	: Laboratory Course-I			
<b>Semester /Year</b>	: IV			
	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
	0	0	4	4

L - Lecture T – Tutorial P – Practical C – Credit

### Course contents

#### A. Laboratory/Field Exercises in Conservation Biology.

1. To study the pattern of regional biodiversity.
2. To study the Hotspots and key-stone species.
3. Survey of biological resources.
4. Study of habitat loss with respect to plant species. To observe factors expediting habitat loss viz., floods, forest fires, landslides, natural and anthropological activities.
5. Visits to national parks, sanctuaries and biosphere reserves of Uttarakhand.

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

1. Growth characteristics of *E. coli* using plating and turbid metric methods.
2. Isolation of plasmid from *E. coli*
3. Demonstration of DNA/ RNA isolation by plant material.
4. Demonstration of protoplast fusion employing PEG.
5. Organogenesis and somatic embryogenesis using appropriate explants and preparation of artificial seed.

### Course outcomes (COs):

Upon successful completion of the course a student will be able to

<b>CO1</b>	Recite, Learn and identify pattern of regional biodiversity and tissue culture.
<b>CO2</b>	Understand and survey of biological resources
<b>CO3</b>	Explain and Collect and enhance information regarding visiting national parks, sanctuaries and biosphere reserves of Uttarakhand
<b>CO4</b>	Analyse the protoplast fusion employing PEG and DNA sequencing by Sanger's di deoxymethod
<b>CO5</b>	Evaluation of the biotechnology process and conservation biology problems.
<b>CO6</b>	Develop the scientific approach toward nature for human welfare.

### Suggested Textbook

1. George, E. F. 1993. Plant Propagation by Tissue Culture. Part 2. In Practice, 2<sup>nd</sup> edition Exegetics Ltd., Edington, UK.
2. Shaw, C. H.(Ed.)1988. Plant Molecular Biology: A Practical Approach. IRL Press, Oxford.

### Reference Book

1. Smith, R.H. 2000. Plant Tissue Culture: Techniques and Experiments. Academic Press, New York.

<b>Course code</b>	: MBOE 404			
<b>Course Name</b>	: Dissertation			
<b>Semester /Year</b>	: IV			
	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
	0	0	10	10

L - Lecture T - Tutorial P - Practical C - Credit

**Course Objectives: The objectives of this course are**

1. The objective of this advanced course is to provide students with hands-on training in specialized areas of plant sciences.
2. To train students in basics of research, literature recession, analysis and expression of their understanding of the topic in their own words.
3. To create research oriented thought process and basic training.

**Course contents**

The student will be reading and analyzing published literature in the chosen area of plant science under direct mentoring of a faculty member and will participate in research activity

**Course outcomes (COs):**

**Upon successful completion of the course a student will be able to**

<b>CO1</b>	Recite the subject knowledge.
<b>CO2</b>	Discuss and understand the scientific temperament.
<b>CO3</b>	Apply the fundamentals of research methodology.
<b>CO4</b>	Focus on the skills for the writing of thesis and scientific papers.
<b>CO5</b>	Justify the knowledge of course work.
<b>CO6</b>	Create awareness and interest towards research.

<b>Course code</b>	: MBOE 405			
<b>Course Name</b>	: Environment Management with reference to Western Himalaya			
<b>Semester /Year</b>	: IV			
	L	T	P	C
	3	0	0	3

L - Lecture T – Tutorial P – Practical C – Credit

**Course Objectives: The objectives of this course are**

1. To develop skills and knowledge for translating the theory and concepts of resource and environmental management into practice relevant to communities and workplaces.
2. To apply monitoring and environmental management tools used by resource and environmental practitioners.
3. To consider the impacts of flows (energy, water, resources/waste) within the built, urban, agricultural and natural environments.

**Course contents**

**Unit 1:** Introduction to the Environmental Management, Major Environmental Problems, Environmental ethics; Resource and conflicts, Environmental Laws; Stockholm Conference, The Earth summit, The Copenhagen Conference, Environmental Protection and Fundamental rights, Environmental Governance in India, Man and Environment, Trade and Environment; the WTO and GATS, Environment Concerns and WTO.

(No. of Hours: 9)

**Unit 2:** Introduction to the Environmental Impact Assessment; Planning and Significance, EIA practices and future trends in India; Legal frame work for EIA. Impact of forest fires, Forest Fire Assessment and Risk Zonation. Thermal power stations, Power line and roads, River valley projects, Urbanization and Industrialization, Mining activities, GHGs, CFCs, fossil fuels etc., Flood monitoring, Snow melt and Glaciers, Ozone Layer Depletion. Principles of Environmental Analysis, Role of remote sensing in EIA. (No. of Hours: 6)

**Unit 3:** Environmental Management and Natural Resources, Air Pollution , Water Pollution and its Management, Environmental Pollution Act; Waste disposal and management, Integrated solid waste management, Recycling, Incineration, Sanitary landfill, Sewage disposal and sewage treatment; Hazardous wastes. Environmental policy and environmental management system, Audit items and audit procedures, ISO Certification. Watershed management: Definition and basic concepts, Aims and Principles, Importance of integrated watershed management, Principal watershed problems of India.

(No. of Hours: 9)

**Unit 4:** Basic concept of ecosystem and community, Biological populations and communities, Ecological niches, interaction among species, Key stone species, Species diversity and edge effects, Major terrestrial and aquatic biomes, Energy Flow, Food webs and trophic levels, Ecosystem diversity, Climate shifts, Species movements. Biodiversity and conservation, In-situ and ex-situ conservation, Indigenous knowledge and biodiversity

conservation, Loss of biodiversity- causes and its impact; Convention on biodiversity, Major Biodiversity resources. Global trends of invasive species, threats and managing invasive plants. Protected areas concept and purpose, type of protected areas and threats, In situ conservation and protected areas; Role of local communities in protected area management.

(No. of Hours: 12)

**Unit 5: Renewable Energy Production and Management:** Energy concepts, present global energy use, future energy needs, renewable needs, energy conservation. Bio fuel plants- Jatropha, sugarcane and oil crops, Bio fuel plantation, energy criteria for species selection, achievement of sustainable Bio fuel production; Bioconversion, utilization of biomass sources, Incineration of organic wastes for energy. Alien invasive species and bio energy production; Bio energy and food production controversies. Carbon sequestration and carbon pools.

(No. of Hours: 9)

### Course outcomes (COs):

Upon successful completion of the course a student will be able to

CO1	Remember and recall the environmental, social and economic framework in which environmental management decisions are made
CO2	Understand and Anticipate and control environmental issues
CO3	Apply Recognize and control factors in the workplace and the environment that cause health and environmental hazards and utilize quantitative knowledge and skills and modern tools and technologies to analyze, plan, and implement environmental management systems
CO4	Analyze, Prepare, review, and update environmental monitoring and assessment Reports and Monitor progress of environmental improvement programs
CO5	Conclude and develop management systems and formulate solutions that are technically sound, economically feasible, and socially acceptable. Assess the potential environmental impact of development projects and design mitigation measures
CO6	Adapt and develop the environmental performance to internal and external clients and regulatory bodies and find professional level employment or pursue higher studies and pursue research for contributing to the betterment of humanity and in shaping a sustainable society

### Suggested Textbooks

1. Heywood, H.V. 1995. Global Biodiversity Assessment.
2. Ramakrishnan, P.S., Saxena, K.G. and Chandra shekara, U.M. 1998. Conserving the sacred for Biodiversity Management. Oxford and IBH Publ. Co. New Delhi
3. Sulphey, M.M. 2015. Introduction to Environment Management. Pp 428. Prentice Hall India Learning Pvt. Ltd.

### Reference Book

1. Ajith Sankar. 2015. Environmental Management. Oxford Univ. Press.

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2. Aggarwal, S.K. 2005. Environmental Management. APH Publishing Corporation.

### CO-PO Mapping

Course	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3	PS O4
CO1	...	2	....	2	1	1	...	2	3	2	1	2	3	2	...	....
CO2	2	...	1	....	3	2	2	...	3	2	1	2	3	....	3	3
CO3	1	...	....	2	3	....	2	2.	2	3	2	2	3	....	3	2
CO4	...	3	1	3	2	2	...	...	2	3	2	2	2	3	2	....
CO5	3	2	2	3	2	2	2	3	2	2	1	2	2	...	2	3
CO6	3	2	3	2	2	2	2	3	2	2	1	2	2	1	2	3

3: Highest Correlated, 2: Medium Correlated, 1: Lowest Correlated

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<b>Course code</b>	: MBOE 406			
<b>Course Name</b>	: Seed Pathology			
<b>Semester /Year</b>	: IV			
	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
	3	0	0	3

L - Lecture T – Tutorial P – Practical C – Credit

**Course Objectives: The objectives of this course are**

To acquaint with seed-borne diseases, their nature, detection, transmission, epidemiology, impacts/loses and management.

**Course content**

**Unit 1:** Introduction, terminology and historical development, seed health and its importance. Kinds of seed borne pathogens: fungi, bacteria, viruses, viroides and nematodes. (No. of Hours: 9)

**Unit 2:** Types of damage caused by the seed borne fungi to seeds and crops. Nature of seed infection. Systemic infection through flower, fruit and seed stock. Penetration through seed coat, natural openings and inflicted openings. (No. of Hours: 9)

**Unit 3:** Longevity of seed borne pathogens. Factors influencing longevity. Epiphytology of seed borne diseases, monocyclic and polycyclic diseases. Detection of seed borne pathogens, objectives of seed health testing. (No. of Hours: 9)

**Unit 4:** Testing methods for seed borne fungi, seed borne bacteria, seed borne viruses and seed borne nematodes. Study of seed borne diseases of certain specific crops, cereals, millets, pulses, oil crops, fibre crops, and vegetable and timber crops. (No. of Hours: 9)

**Unit 5:** Control of seed borne pathogens: selection of seed production areas, crop management, seed treatment, certification, and plant quarantine and disease resistance. (No. of Hours: 9)

**Course outcomes (COs):**

**Upon successful completion of the course a student will be able to**

<b>CO1</b>	Remember the basics of seed pathology.
<b>CO2</b>	Understand about the kinds of seed borne pathogens.
<b>CO3</b>	Explain the Infer the types of damage caused by the seed borne fungi to seeds and crops.
<b>CO4</b>	Apply and Learn the nature of seed infection, longevity of seed borne pathogens, Epiphytology of seed borne diseases, monocyclic and polycyclic diseases.
<b>CO5</b>	Summarized the methodology of detection of seed borne pathogens.

<b>CO6</b>	Develop the knowledge of Seed Pathology.
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**Suggested Textbook**

1. Neegard P. 1977. Seed Pathology Vol I and II. MacMillan Press, London
2. Suryanarayan, D. 1978. Seed Pathology. Vikas Publ. House. Pvt. Ltd. New Delhi.
3. Jha, D.K. 1995. A Text Book of Seed Pathology. Vikas Publ. House. Pvt. Ltd. New Delhi.
4. Agarwal, V.K. 1978. Principles of Seed Pathology. In (ed.) James B.S. Sindair. CRC Press. II Edition.

**Reference Book**

1. Singh, Gurnam, Seed Pathology. Pointer Publisher, Jaipur.
2. Sing, T. Seed Technology and Seed Pathology. Pointer Publisher, Jaipur.
3. Nene, Y.L. and Agarwal, V.K. 1978. Some seed borne diseases and their control. ICAR, New Delhi

**CO-PO Mapping**

Course	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3	PS O4
CO1	1	2	3	3	2	1	2	...	2	3	2	1	1	3	2	1
CO2	1	3	2	2	1	2	2	2	3	2	3	3	2	2	3	2
CO3	3	2	2	3	2	2	3	2	3	1	3	2	2	2	3	3
CO4	3	3	2	2	2	...	1	3	2	3	2	.....	3	3	2	2
CO5	1	2	2	1	1	3	2	3	2	1	1	2	2	2	3	1
CO6	2	2	2	3	1	2	2	2	...	3	1	3	2	3	1	2

3: Highest Correlated, 2: Medium Correlated, 1: Lowest Correlated

<b>Course code</b>	: MBOL 407			
<b>Course Name</b>	: Laboratory Course-II			
<b>Semester /Year</b>	: IV			
	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
	0	0	3	3

L - Lecture T – Tutorial P – Practical C – Credit

### Course contents

#### A. Practical Based on MBOE 405

1. Identification of Key stones pecies.
2. To study phytoplankton and benthos in aquatic bodies.
3. Analysis of water for dissolved oxygen.
4. Estimation of biological oxygen demand and chemical oxygen demand.
5. Case study of any hydroelectric power project in Uttarakhand with EIA prospective using remote sensing and GIS.

#### B. Practical Based on MBOE406

1. Field inspection of seed crops and visual examination of seeds for infections.
2. Seed soaking for the detection of certain seed borne pathogens (fungi) and nematodes.
3. Seed washing tests and incubation methods.
4. Seedlings symptomatology tests.
7. Detection of bacteria by Agar Plate methods.
8. Viruses: Physical examination, Grow out tests, Enzyme linked immune absorbent assay (ELISA) and Polymerase Chain Reaction (PCR).
9. Visit to seed processing plants and seed testing laboratory.
10. Reduction of seed inoculum by chemical seed treatments.
11. Testing amount of pesticides in treated seeds

### Course outcomes (COs):

Upon successful completion of the course a student will be able to

<b>CO1</b>	Recite the understanding of seed soaking method for the detection of seed borne pathogens.
<b>CO2</b>	Understand and Learn identification of key stone species
<b>CO3</b>	Apply and Enumerate phytoplankton and benthos from aquatic bodies
<b>CO4</b>	Illustrate the agar plate method for the detection of bacteria and fungi
<b>CO5</b>	Evaluate and estimate and analyse BOD, COD and DO of water.
<b>CO6</b>	Create an idea to develop problems solving approach.

### Suggested Textbook

1. Frank, B. Friedman. 2011. A Practical guide to Environmental Management. 11<sup>th</sup> ed. Environment Law Institute.
2. Ram Prakash, Archana Sharma, O.P. Chaubey. Seed Technology and Seed Pathology. Pointer Publisher, Jaipur.

**Reference Book**

1. Khullar and Rao. 2021. Environment and Disaster Management. McGraw Hill Education India Pvt. Ltd.

**CO-PO Mapping**

Course	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3	PS O4
CO1	3	...	2.	2	2	2	...	1	3	2	...	.....	3	2	3	2
CO2	1	3	2	2	1	2	2	2	3	2	3	3	2	2	2	3.
CO3	3	2	2	3	2	2	3	2	3	1	3	2	2	2.	2	2
CO4	2	1	2	2	2	...	1	3	2	3	2	.....	3	2	1	3
CO5	1	3	2	1	1	3	2	3	2	1	2	3	2	2	2	2.
CO6	3	3	2	3	1	2	2	2	...	3	2	3	2	3	3	2

3: Highest Correlated, 2: Medium Correlated, 1: Lowest Correlated

<b>Course code</b>	: MBOS 408			
<b>Course Name</b>	: Analytical Techniques in Plant Sciences			
<b>Semester /Year</b>	: IV			
	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
	3	0	0	3

**Course Objectives: The objectives of this course are**

1. To gain the knowledge on various techniques and instruments used for the study of plant biology.
2. Understanding of principles and use of light, confocal transmission and electron microscopy, centrifugation, spectrophotometry, chromatography, x-ray diffraction technique and chromatography techniques.

**Course contents**

**Unit 1:** Imaging and related techniques Principles of microscopy; Light microscopy; Fluorescence microscopy; Confocal microscopy; Use of fluorochromes: (a) Flow cytometry (FACS); (b) Applications of fluorescence microscopy: Chromosome banding, FISH, chromosome painting; Transmission and Scanning electron microscopy – sample preparation for electron microscopy, cryofixation, negative staining, shadow casting, freeze fracture, freeze etching. (No. of Hours: 14)

**Unit 2:** Cell fractionation Centrifugation: Differential and density gradient centrifugation, sucrose density gradient, CsCl<sub>2</sub> gradient, analytical centrifugation, ultracentrifugation, marker enzymes. (No. of Hours: 6)

**Unit 3:** Radioisotopes Use in biological research, auto-radiography, pulse chase experiment. Spectrophotometry Principle and its application in biological research. (No. of Hours: 4)

**Unit 4:** Chromatography Principle; Paper chromatography; Column chromatography, TLC, GLC, HPLC, Ion exchange chromatography; Molecular sieve chromatography; Affinity chromatography. Characterization of proteins and nucleic acids. Mass spectrometry; X-ray diffraction; X-ray crystallography; Characterization of proteins and nucleic acids; Electrophoresis: AGE, PAGE, SDS-PAGE. (No. of Hours: 14)

**Unit 5:** Biostatistics Statistics, data, population, samples, parameters; Representation of Data: Tabular, Graphical; Measures of central tendency: Arithmetic mean, mode, median; Measures of dispersion: Range, mean deviation, variation, standard deviation; Chi-square test for goodness of fit. (No. of Hours: 6)

**Course outcomes (COs):**

Upon successful completion of the course a student will be able to

<b>CO 1</b>	Remember the Imaging and related techniques, Cell fractionation, Radioisotopes, Spectrophotometry, Chromatography and Biostatistics
<b>CO 2</b>	Understand to use electrophoresis and Blotting techniques for DNA, RNA, and, protein characterization, paper chromatography for nitrogenous bases separation by, layer chromatography for sugar separation, prepare slides for microscopic studies
<b>CO 3</b>	Apply and Understand principles and technicality of Mass spectroscopy, X-ray diffraction, X-ray crystallography and various types of electrophoresis techniques.
<b>CO4</b>	Analyze the applications of paper chromatography, column chromatography, TLC, GLC, HPLC
<b>CO5</b>	Summarized the principles of different types of microscopy; types of centrifugation, spectrophotometer, chromatography; techniques of characterization of proteins and nucleic acids; use of radioisotopes in biological research; preliminary biostatistics
<b>CO6</b>	Develop the knowledge about Analytical Techniques in Plant Sciences.

**Suggested Textbooks:**

1. Ruzin, S.E. (1999). Plant Micro technique and Microscopy, Oxford University Press, New York. U.S.A
2. S.D. Ramteke and J.H. Meshram. (2019). Plant Analytical Techniques, p236, Daya Publication House, New Delhi

**Reference Books:**

1. Plummer, D.T. (1996). An Introduction to Practical Biochemistry. Tata McGraw- Hill Publishing Co. Ltd. New Delhi. 3rd edition.
2. Ausubel, F., Brent, R., Kingston, R. E., Moore, D.D., Seidman, J.G., Smith, J.A., Struhl, K. (1995). Short Protocols in Molecular Biology. John Wiley & Sons. 3<sup>rd</sup>edition.
3. Zar, J.H. (2012). Biostatistical Analysis. Pearson Publication. U.S.A. 4th edition.

**CO-PO Mapping**

Course	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3	PS O4
CO1	2	3	....	3	2	2	...	1	3	2	...	....	2.	2	3	1
CO2	3	2	3	2	1	2	2	2	3	2	3	3	2	2	3	2
CO3	1	2	2	2	2	2	3	2	3	1	3	2	2	2.	3	2
CO4	2	3	....	1	2	...	1	3	2	3	2	....	2	2	2	3
CO5	1	2	3	2	1	3	2	3	2	1	2	3	2	2	2	3
CO6	2	2	3	3	1	2	2	2	...	3	2	3	2	3	...	2

3: Highest Correlated, 2: Medium Correlated, 1: Lowest Correlated

<b>Course code</b>	: MBOS 409			
<b>Course Name</b>	: Nursery and Gardening			
<b>Semester /Year</b>	: IV			
	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
	3	0	0	3

**Course Objectives: The objectives of this course are**

1. To gain knowledge of gardening, cultivation, multiplication, raising of seedlings of ornamental plants.
2. Students would have an understanding of:
  - a. How nursery of the plants is prepared?
  - b. How rooting is promoted in the stem cuttings?
  - c. How seeds are stored and what are the soil conditions for seed sowing and seedling growth?
  - d. How can we design land scaping.

**Course content**

**Unit 1:** Nursery: definition, objectives and scope and building up of infrastructure for nursery, planning and seasonal activities - Planting - direct seeding and transplants.

(No. of Hours: 8)

**Unit 2:** Seed: Structure and types - Seed dormancy; causes and methods of breaking dormancy - Seed storage: Seed banks, factors affecting seed viability, genetic erosion - Seed production technology - seed testing and certification.

(No. of Hours: 9)

**Unit 3:** Vegetative propagation: air-layering, cutting, selection of cutting, collecting season, treatment of cutting, rooting medium and planting of cuttings - Hardening of plants - green house - mist chamber, shed root, shade house and glass house.

(No. of Hours: 9)

**Unit 4:** Gardening: definition, objectives and scope - different types of gardening - landscape and home gardening - parks and its components - plant materials and design - computer applications in landscaping - Gardening operations: soil laying, manuring, watering, management of pests and diseases and harvesting.

(No. of Hours: 10)

**Unit 5:** Sowing/raising of seeds and seedlings - Transplanting of seedlings - Study of cultivation of different vegetables: cabbage, brinjal, lady's finger, onion, garlic, tomatoes, and carrots - Storage and marketing procedures.

(No. of Hours: 9)

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**Course outcomes (COs):**

Upon successful completion of the course a student will be able to

<b>CO 1</b>	Describe the objectives and scope of Nursery, Gardening and cultivation of various vegetables.
<b>CO 2</b>	Explain about the structure and types of seed, seed dormancy, Seed production technology, seed testing and certification etc.
<b>CO 3</b>	Illustrate the methods of Nursery, Gardening and vegetative propagation.
<b>CO4</b>	Analyze the definition, objectives and scope of different types of Nursery & gardening
<b>CO5</b>	Summarized the knowledge sowing and raising of seeds and seedlings, transplanting and cultivation of seedlings and marketing procedures of vegetables.
<b>CO6</b>	Design the idea of Nursery and Gardening.

**Suggested Textbooks**

1. Bose T.K. & Mukherjee, D., 1972, Gardening in India, Oxford & IBH Publishing Co., New Delhi.
2. Sandhu, M.K., 1989, Plant Propagation, Wile Eastern Ltd., Bangalore, Madras.
3. Kumar, N., 1997, Introduction to Horticulture, Rajalakshmi Publications, Nagercoil.

**Reference Book**

1. Edmond Musser & Andres, Fundamentals of Horticulture, McGraw Hill Book Co., New Delhi.
2. Aggrawal, P.K. 1993, Hand Book of Seed Technology, Dept. of Agriculture and Cooperation, National Seed Corporation Ltd., New Delhi.

**CO-PO Mapping**

Course	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3	PS O4
<b>CO1</b>	1	2	3	3	2	1	2	...	2	3	2	1	1	3	2	1
<b>CO2</b>	1	3	2	2	1	2	2	2	3	2	3	3	2	2	3	2
<b>CO3</b>	3	2	2	3	2	2	3	2	3	1	3	2	2	2	3	3
<b>CO4</b>	3	3	2	2	2	...	1	3	2	3	2	.....	3	3	2	2
<b>CO5</b>	1	2	2	1	1	3	2	3	2	1	1	2	2	2	3	1
<b>CO6</b>	2	2	2	3	1	2	2	2	...	3	1	3	2	3	1	2

3: Highest Correlated, 2: Medium Correlated, 1: Lowest Correlated

# SHRI GURU RAM RAI UNIVESITY

PATEL NAGAR, DEHRADUN-248001, UTTARAKHAND, INDIA

[Estd. by Govt. of Uttarakhand, vide Shri Guru Ram Rai University Act no. 03 of 2017 & recognized by UGC u/s 2(f) of UGC Act 1956]



## SYLLABUS FOR Pre Ph.D. Botany School of Basic & Applied Sciences

(w.e.f 2023-2024)

SHRI GURU RAM RAI UNIVERSITY, PATELNAGAR, DEHRADUN-  
UTTARAKHAND-248001

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**PRE- Ph. D. COURSE IN BOTANY**

Course Code	Course Title	Credit	Marks for		Total Marks
			IA*	EE**	
<b>Core Paper</b>					
PRMC 101	Research methodology	4	20	60	80
RPEC 102	Research & Publications Ethics	2	10	30	40
PBOC103	Plant Science: Basics and Applied Aspects	4	20	60	80
<b>Optional Paper</b>					
PBOE104	Biodiversity, Resource Botany and Ethnobotany	4	20	60	80
PBOE105	Habitat Ecology, Environment and Natural Resource Management and Remote Sensing	4	20	60	80
PBOE106	Basic and Applied Palynology	4	20	60	80
PBOE107	Plant Pathology and Pathogen Interaction	4	20	60	80
<b>Compulsory Paper</b>					
PBOF108	Field Work	4	80	-	80
		<b>Total</b>	<b>210</b>	<b>390</b>	<b>600</b>

**CORE COURSE****PRMC 101: RESEARCH METHODOLOGY****Credit: 04****Course Outcome: The student will be able to**

- CO-1 To develop understanding of the basic framework of research process.  
CO-2 To develop an understanding of various research designs and techniques.  
CO-3 To identify various sources of information for literature review and data collection.  
CO-4 To develop an understanding of the ethical dimensions of conducting applied research  
CO-5 Appreciate the components of scholarly writing and evaluate its quality.  
CO-6 To create the research design and experimental approaches to conduct research.

**Unit I-Concept & Types of Research**

Meaning and importance of Research, Types of Research, Selection and formulation of Research Problem, Research Design, Classification of Research, Pure and Applied Research, Exploring or Formulative Research, Descriptive Research, Diagnostic Research/Study, Evaluation research/Studies, Action Research, Experimental Research, Historical Research.

**Unit II –Methods Research**

General Survey of various Methods including Survey Method, Interdisciplinary Method, Case Study Method, Sampling Method, Observation Method, Interview Method, Schedule Method, Questionnaire Method, Documentary Method, Library Method, Historical Method and Scientific Method. Characteristic Features of Scientific Method; Empirical Verifiable, Cumulative, Self - Correcting, Deterministic, Ethical & Ideological neutrality (Value Free).

**Unit III - Data Collection and Data Analysis**

Collection, Objectives and Classification of Data, Aims, Methods and Objects of Tabulation of Data, Forms and Processes of Interpretation and Presentation of Data, Primary, Secondary and Tertiary Data, Construction and adaptation of instruments, administration of questions and tests, Data organization in SPSS & Excel, Graphical representation of data, Testing of Hypothesis: Logical and Statistical Techniques.

**Unit IV- Report Writing**

Locating Information on a Topic of Interest, Acquiring Copies of Articles of Interest, The Nature of Scientific Variables, Conceptual Versus Operational Definitions of Variables, Levels of Measurement, Various Paradigms, The Basic Format for a Research Report, Identification of the Parts of a Research Report, Citation and Referencing Styles, Essentials of Report Writing, Aids for Writing Good Research Report.

**Suggested Readings:**

- 1) Bagchi, Kanak Kanti (2007) Research Methodology in Social Sciences: A Practical Guide, Delhi, Abijeet Publications.
- 2) Kothari, C.R (2004) Research Methodology: An Introduction, Delhi, New Age.
- 3) Cooper, R. Donald and Pamela S. Schindler (2003) Business Research Methods, Delhi, Tata McGraw-Hill.
- 4) Flyvbjerg, Bent (2001) Making Social Science Matter: Why Social Inquiry Fails and How it can Succeed Again, United Kingdom, Cambridge University Press.
- 5) Goodde and Hatte (1952) Methods in Social Research, New York, McGraw – Hill.

**RPEC-102: RESEARCH AND PUBLICATION ETHICS****Credit: 02****Course Outcome: The student will be able to**

- CO-1 To develop an understanding of research ethics, publications misconduct and plagiarism.
- CO-2 To develop Intellectual honesty and research integrity.
- CO-3 To identify various sources of information for data bases and research matrices.
- CO-4 To develop an understanding of Open access publications and initiatives.
- CO-5 Appreciate the components of scholarly writing and evaluate its quality.
- CO-6 To create the research matrices based on cite score.

**Unit I-Philosophy and Ethics**

Introduction to philosophy: definition, nature and scope, concept, branches. Ethics: definition moral philosophy, nature of moral judgements and reactions.

**Unit II-Scientific Conduct**

Ethics with respect to science and research, Intellectual honesty and research integrity, Scientific misconducts: Falsification and Plagiarism (FFP), Redundant publication: duplicate and overlapping publication, salami slicing, Selective reporting and misrepresentation of data.

**Unit III-Publication Ethics**

Publication ethics: definition, introduction and importance, Best practices / standards setting initiatives and guidelines: COPE, WAME, etc. Conflicts of interest, Publication misconduct: definition, concept, problems that lead to unethical behavior and vice versa, types, violation of publication ethics, authorship and contributor ship, Identification of publication misconduct, complaints and appeals, Predatory publishers and journals Practice.

**Unit IV-Open Access Publishing**

Open access publications and initiatives, SHERPA / RoMEO online resource to check publisher copyright and self-archiving policies, Software tools to identify predatory publications developed by SPPU, Journal finder / journal suggestion tools viz. JANE, Elsevier journal Finder, Springer, Journal Suggester, etc.

**Unit V-Publication Misconduct**

Group Discussion, Subject specific ethical issues, FFP, authorship, Conflicts of interest, Complaints and appeals: examples and fraud from India and abroad. Software tools, Use of plagiarism software like Turnitin, Urkund and other open source software tools.

**Unit VI-Databases and Research Metrics**

Databases, Indexing databases, Citation databases: Web of Science, scopus, etc., Research Metrics, Impact factor of journal as per journal Citation report, SNP, SJR, IPP, Cite score, Metrics: h-index, g index, i10 index, altmetrics.

**PBOC 103: PLANT SCIENCE: BASICS AND APPLIED ASPECTS****Credit: 04****Course Outcome: The student will be able to**

- CO-1 Knowledge about the thallus, classification, ecology and identification related to lower cryptogams and phanerogams.
- CO-2 Learn the classification, distribution, economic and ecological importance of Gymnosperms in India with special reference to Himalaya.
- CO-3 Understand the concept of diffusion, osmosis and water potential.
- CO-4 Understand the structure, composition and functional mechanisms of various biologically important molecules like carbohydrates, amino acids, proteins and lipids.
- CO-5 Identify and apply classical and modern tools and methods of plant breeding.
- CO-6 Learn the basic and advanced concepts, principles and applications of plant tissue culture and genetic engineering.

**Unit I. Cryptogams:**

Classification, habit and habitats; Diversity and ecological adaptation; Methods of collection, preservation and identification; Research Journals devoted to lower plants.

**Unit II. Phanerogams:**

Identification and distribution of Himalayan Gymnosperms with their aesthetic and economic importance. Diagnostic features for classification of flowering plants; Himalayan flora and biodiversity; Conservation status of important Himalayan species;

**Unit III. Physiology and Biochemistry:**

Functions of biological molecules, cell and organisms as biochemical entities; Metabolism and biochemical energetics. Biochemical techniques: Buffers, pH, strength of solution, acids, bases, homogenization, differential centrifugation and chromatography. Isotopic tracer techniques

**Unit IV: Plant Breeding:**

Objectives, activities and achievements. Breeding methods for self, cross pollinated and clonal crops; Breeding for resistance to various stresses and quality; Biotechnology applications in crop improvement, IPR and plant breeders rights (PBR).  
Green Revolution.

**Unit V: Genetic Engineering and Biotechnology:**

Concepts and new Achievements

**Suggested Reading**

1. Mehrotra, R.S. and Aneja, R.S. 1998. An Introduction to Mycology. New Age Intermediate Press.
2. Kumar, H.D. 1988. Introductory Phycology. Affiliated East-West Press Ltd., New Delhi.
3. Smith, G.M. 1955. Cryptogamic Botany. Vol. I and II. Tata Mc Graw Hill, New Delhi.
4. Bhatnagar, S.P. and Mitra, A. 1996. Gymnosperms. New Age International Pvt. Ltd., New Delhi.
5. Gaur, R.D. 1999. Flora of District Garhwal: NW Himalaya. Transmedia, Srinagar, Garhwal.
6. Stace, C.A. 1989. Plant Taxonomy and Biosystematics (2edition). Edward Arnold Ltd., London.
7. Singh, B.D. 2002. Plant Breeding Principles and Methods. Kalyani Publ. New Delhi.
8. Noggle, G.R and Fritz, G.F. 1977. Introductory Plant Physiology. Prentice Hall. New Delhi.

9. Salisbury, F.B. and Ross, C.W. 1992. Plant Physiology (4<sup>th</sup> edition). Wadsworth Publishing Co., California, USA.
10. Bhojwani, S.S. and Razdan, M.K. 1996. Plant Tissue Culture: Theory and Practice (a revised edition). Elsevier Science Publishers, New York, USA.
11. Bhojwani, S.S. 1990. Plant Tissue Culture: Applications and Limitations. Elsevier Science Publishers, New York, USA.
12. Shantharam, S. and Montgomery, J.F. 1999. Biotechnology, Biosafety & Biodiversity. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi.

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**OPTIONAL COURSE****PBOE104: BIODIVERSITY, RESOURCE BOTANY AND ETHNOBOTANY Credit : 4****Course outcome: The students will be able to**

- CO-1 Understand the global and regional patterns of biodiversity.  
CO-2 Learn the concepts and principles, threats and conservation of biological diversity.  
CO-3 Learn the concept of species extinction, endangered species, Red and Green Data Books.  
CO-4 Apply the taxonomic evidences and taxonomic tools.  
CO-5 Learn the concepts of Ethnobotany and its study tools with special reference to Himalaya.  
CO-6 Learn the importance of Sanctuaries, National Parks and Biosphere Reserves.

**Unit I**

1. Biodiversity: Concept, biodiversity of major groups including microbial biodiversity, distribution, maintenance and loss of biodiversity.
2. Concepts of species in relation to biodiversity and systematics.
3. Biodiversity in India. Species and genetic biodiversity with reference to Himalaya.

**Unit II**

1. Taxonomic tools in the study of biodiversity: Nomenclature, herbaria, floras, monographs, histological, cytological, phytochemical, and serological and biochemical techniques.
2. Plant collection and preservation techniques.
3. Dynamics of floristic diversity: Concept of phytogeography: Endemism, hotspots; invasions and introduction.
4. Plant exploration in India with special reference to North-West Himalaya.

**Unit III**

1. Concept of threatened categories (rare, endangered, vulnerable), Red Data Book.
2. Conservation of Biodiversity: Concept, Environmental policies, Biosphere Reserves, National Parks, Sanctuaries, Botanical Gardens, Pollen storage and Seed Banks, Tissue culture and role of biotechnology in conservation of biodiversity; Cryopreservation. CITES, IUCN, The criteria for assessment of rare plant conservation; Environmental awareness and people's participation in conservation of biodiversity.

**Unit IV**

1. Identification and evaluation of biodiversity particularly with reference to plant resources:
  - a. Cultivated: brief account of cultivated plant diversity
  - b. Wild: Detailed account of wild plant diversity with reference to food, fodder, timber, medicine, dyes, tannins, beverages, essential oils and aesthetics with particular reference to north-west Himalaya; Wild relatives of cultivated plants, weeds and aliens.

**Unit V**

1. Ethnobotany: concept, methods of study and analysis, linkage with other sciences, world perspectives, Indian perspectives. Traditional knowledge in natural resource

utilization and conservation with particular emphasis on germplasm conservation.

2. Basic knowledge of Intellectual Property Rights (IPR).

**Suggested Readings:**

1. Lawrence, H.W. 1951. Taxonomy of Vascular Plants. Reprint Oxford and IBH, New Delhi.
2. P.C. Trivedi and Niranjana Sharma. (2017). Plant Resource Utilization and Conservation. Pointer Publication, Jaipur.
3. Singh, J.S., Singh, S.P., Gupta, S. (2006). Ecology, Environment and Resource Conservation. New Delhi, India: Anamaya Publications.
4. Dhar, U. 1993 (Ed.). Himalayan Biodiversity: Conservation Strategies, Gyanodaya Prakashan, Nainital.
5. Groombridge, B. and Jenkins, M.D. 2000. Global Biodiversity. Earth's living resources in the 21st century, UK. World conservation Monitoring Center. Pp 246.

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**PBOE 105: HABITAT ECOLOGY, ENVIRONMENT AND NATURAL RESOURCE MANAGEMENT AND REMOTE SENSING****Credit: 4****Course outcome: The student will be able to**

- CO-1- Understand the organization and development of vegetation of Himalayas.  
CO-1- Understand the traditional knowledge of Non-timber forest products, medicinal and aromatic plants.  
CO-3- Learn and analyse the climate change and its consequences in relation to the CO<sub>2</sub> fertilization, global warming, sea level rise and threats of UV radiation.  
CO-4- Understand the fundamentals, and applications of remote sensing in ecological and forestry research.  
CO-5- Understand the natural resources, their classification and consumption pattern emphasizing with sustainability of natural resource.  
CO-6- Critically think about environment impact assessment, planning and significance.

**Unit I**

Habitat Ecology: Introduction to Habitat Ecology, Ecological and evolutionary perspectives and concepts; Major habitats, deserts, grasslands and forests, wetlands; Classification, functions and values; Factors affecting wetlands habitats.

Factors influencing terrestrial habitats: drought, floods, tides, soil erosion, grazing, lopping, felling, fire, encroachment, pollution, developmental projects, successional changes and wild life habitats.

**Unit II**

Natural Resource Management: Natural resources- introduction, classification, utilization, consumption pattern with emphasis on sustainability of natural resources. Policies and strategies for appropriate sustainable resource management and its potential to livelihood security.

**Unit III**

Environment Management: Concept of environment management; Environmental protection and fundamental rights; Man and environment.

Environment Impact Assessment (EIA); Planning and significance; EIA Reports and environment management plans; Case study.

Disaster Management, Classification; Concepts of land slides and earthquakes in Uttarakhand Himalaya and its mitigation.

Global warming and climatic change; Indicators and consequences, loss of biodiversity.

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Impact of climatic change on natural resources and strategies for mitigation.

**Unit IV**

Applied Ecology: Forest types of Uttarakhand and other Himalayan provinces, Forest heritage in Garhwal Himalaya; Classification; forest products (NTFPs, medicinal and aromatic plants, fibre, etc.); Ethnobotanical heritage (traditional health care and knowledge system). Wildlife, Protected area management. Introduction to Silviculture, Floriculture and Pomology.

**Unit V**

Remote Sensing: Principles and Practical applications of Remote Sensing techniques.

Interpretation of photographs and imagery; Digital analysis of imagery.

Geographic Information System; Principles and basics of GIS; Applications in terrestrial and aquatic habitats.

Basics of Global Positioning System, GPS satellite and GPS utility.

**Suggested Readings:**

1. Barbour, M.G., Burk, J.H. and Pitts, W.D. 1987. Terrestrial Plant Ecology. Benjamin/Cummings Publication Company, California
2. Begon, M., Harper, J.L. and Townsend, C.R. 1996. Ecology. Blackwell Science, Cambridge, USA
3. Chapman, J.L. and Reiss, M.J. 1988. Ecology: Principles and Applications. Cambridge University Press, Cambridge, U.K.
4. Heywood, H.V. 1995. Global Biodiversity Assessment.
5. Lochwood, M., Worboys, G.L. and Ashish, K. 2006. Managing Protected Areas: A Global Guide.
6. Odum, E.P. 1983. Basic Ecology. Saunders, Philadelphia
7. Smith, R.L. 1996. Ecology and Field Biology. Harper Collins, New York.
8. Singh, J.S. Singh, S.P. and Gupta, S.R. 2005. Ecology, Environment and Resource Conservation. Anamaya Publ., F-154/2 Ladosarai, New Delhi- 110 030. anamayapub@vsnl.net.in

**PBOE 106: BASIC AND APPLIED PALYNOLOGY****Credit: 4****Course outcome: The students will be able to**

- CO1- Remember about the general concepts of palynology and understand the process of microsporogenesis, formation of microspore tetrads and polarity of spores and pollen grains.
- CO2- Understand structure and development of pollen wall development.
- CO3- Examine the morphological features of Spore-pollen.
- CO4- Analyze and identify the various aspects of Palyno-taxonomy
- CO5- Summarized the importance of Aeropalynology with reference to allergy.
- CO6- Generalized the concepts Palynology and Pollination Biology

**Unit I**

**Palynology:** General Introduction and history, Importance of Palynology in plant taxonomy, pollen biotechnology, aerobiology and pollen allergy, forensic palynology, melissopalynology, palaeopalynology and in hydrocarbon exploration.

**Unit II**

**Microspores tetrads and polarity of spores and pollen grains. Pollen spore morphology:** symmetry, shape, size. Exine stratification, NPC system for numerical expression, Apertural details, exine stratification, surface structure and sculpture of sporoderm, LO analysis and edge analysis, chemical nature of sporopollenin, development of pollen wall, ubisch body and exineless pollen grains.

**Unit III**

**Melisso palynology:** Definition, history and scope. Melissopalynological research in India.

**Honey:** definition, composition, chemical and physical characteristics, deterioration, heavy metal contamination and adulteration. Bee products.

**Methods in Melissopalynology:** Qualitative and quantitative analysis (According to International Commission for Bee Botany), Estimation of absolute number of plant elements in honey.

Botanical and geographical origin of honey.

**Unit IV**

**Apiculture:** Definition, history and scope. Apicultural research in India.

Different species of bees, morphology, anatomy, colony organization and life cycle, social behaviour of bees, reproduction, queen rearing.

**Unit V**

Bee keeping equipment, Seasonal management, Bee enemies and bee diseases. Role of bees in increasing the productivity of agro-horticultural crops in Indian Economy.

Recent trends in Apiculture. Role of bee keeping in rural development.

**SUGGESTED READINGS:**

1. Crane, Eva., Walker, Penelope and Day Rosemany. 1984. Directory of Important World Honey Sources: International Bee Research Association, London.
2. Erdtman, G. 1952. Pollen Morphology and Plant Taxonomy, Angiosperms; Almquist and Wiksell, Stockholm.
3. Nair, P.K.K. 1966. Essentials of Palynology; Asia Publication House, Lucknow.
4. Wodehouse, R.P. 1935. Pollen Grains: Hafner Publication Co.

**PBOE 107: PLANT PATHOLOGY AND PATHOGEN INTERACTION****Credit: 4****Course outcomes:**

CO-1 Remember the concepts of nomenclature and classification, fungal biodiversity, reproduction in fungi.

CO-2 Understand the knowledge of plant viruses in terms of composition, structure and nature of plant viruses.

CO-3 Develop procedure for understanding of evolution, classification and nomenclature of plant-pathogenic bacteria.

CO-4 Explain in detail different plant management strategies.

CO-5 Summarized the biology of major, and emerging pathogens and pests of crop plants

CO-6 Combine theoretical and practical knowledge of plant disease and pest management

**Unit I**

Types of plant pathogens, mode of infection, pathogenesis strategies –fungus, bacteria, nematodes, nonhost pathogens, viruses, subviral agents viroids, satellite viruses, satellite RNAs. Initial establishment, multiplication and spread of pathogens, symptoms host ranges

**Unit II**

Nature, causes and classification of plant pathogen; Dissemination and methods of preservation and control of plant diseases, Host-parasite relationship, plant defense mechanism.

**Unit III**

Fungal disease of plant crops- rice, wheat, maize, sugarcane, cotton and groundnut; fruit crops- apple, peach, mango, citrus and grapes; vegetable crops- crucifers, tomato, potato and brinjal; other crops- tobacco, turmeric and coriander.

**Unit IV**

Bacterial diseases of field crops, vegetable, fruits and other economically important plants. Viral diseases of field crops, vegetable, fruits and other economically important plants. Nematode disease of plants: a knowledge of some important nematode disease of economically important crops.

**Unit V**

Application of biofertilizers in production of healthy and vigorous transplants in nursery. Role of mycorrhiza in growth of plants.

**SUGGESTED READING:**

1. Mehrotra, RS. 1980. Plant Pathology. Tat McGrawHill.
2. Singh, RS. 1998. Plant Disease. Oxford & IBH Publ.
3. Bilgrami, KS. &Dubey, H.C. 1976. Vikas Publ. House, New Delhi.

**PBOF108: FIELD WORK**

**CREDIT: 4**

Assessment will be based on work assigned by head of the department like to attend or present research paper/s in Seminar/ conference, write up on review literature and field visits for sample collection/tour report submission etc.

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**List of Supplementary Books as Advised External Expert BOS-2023-2024.**

1. Annie Ragland, V. Kumaresan, N. Arumugam.2011. Algae, Fungi, Bryophytes, Microbiology, and Plant Pathology 2<sup>nd</sup> Edition. Saras Publication, p752.
2. T.S. Dhaka. 2022. Microbes, Algae, Fungi, and Bryophytes. 3<sup>rd</sup> Edition. Pragati Prakashan Meerut, p312.
3. B.P. Pandey. 2023. Botany for B.Sc. Students: Pteridophytes, Gymnosperms, and Angiosperms. S, Chand Publ. p624.
4. Bhatnagar S.P, Dantu, P.K. Bhojwai S.S. (2018). The embryology of Angiosperms. Vikas Publ. House. New Delhi.
5. Sharma, P.C. (2017). Text Book of Plant Anatomy. Arjun Publishing House.
6. Rastogi, V.B. (2019). Genetics. 4th Edition. MEDTECH: A Division of Scientific International.
7. Russel P. J. (2010). Genetics-A Molecular Approach, Pearson Education Inc.
8. R.S. Shukla and P.S. Chandel. 2020. Revised edition. Cytogenetics, Evolution, Biostatistics, and Plant Breeding. S. Chand Publ. New Delhi.
9. Ram J. Singh. 2021 (Revised Edition). Plant Cytogenetics, CRC Press.
10. Bhojwani, SS, Bhatnagar, SP., and Dantu, P.K. 2015. 6<sup>th</sup> Edition. Embryology of Angiosperms. Vikas Publishing House, New Delhi. P376.
11. S.L. Kochhar.5<sup>th</sup> Edition. 2016. Economic Botany: A Comprehensive Study. Cambridge University Press, p680.
12. George Acquaah. 2021. Principles of Plant Genetics and Breeding (3<sup>rd</sup> Edition). John Wiley & Sons, UK. P848.
13. SK Verma, and Mohit Verma. 2008. A Text Book of Plant Physiology, Biochemistry and Biotechnology. S. Chand Publ., p238.
14. Manju Bala, Sunita Gupta, and N.K. Gupta. 2013. Practicals in Plant Physiology and Biochemistry. Scientific Publishers, p196.
15. C. Manoharachary, K. V. B. R. Tilak, K. V. Mallaiah, Indra Kala Kunwar. 2016. Mycology and Microbiology (A Textbook for UG and PG Courses). Scientific Publishers, p607.
16. Sarah C. Watkinson, Lynne Boddy, Nicholas Money. 2015. The Fungi. Elsevier Science, p466.
17. B.D. Singh. 2022. Plant Breeding: Principles and Methods. Scientific International, p911.
18. Nalini Chandar, Susan Viselli · 2019. Cell and Molecular Biology. Wolters Kluwer Publ.p259.
19. H. S. Chawla · 2018. Plant Biotechnology. CBS Publishers & Distributors, p728.
20. Jan Lepš, Petr Šmilauer · 2020. Biostatistics with R: An Introductory Guide for Field Biologists
21. RS Ambasht. 2022. A Textbook of Plant Ecology 16th Edition, CBS Publishers & Distributors, p488.
22. A. V. S. S. Sambamurty. 2013. Taxonomy of Angiosperms. I. K. International Pvt Ltd, p908.
23. C. Ushamalini. et al. 2022. An Introduction to Forest Pathology. Narendra Publishing House.

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