

**Himachal Pradesh University,
Summer Hill, Shimla 171005 H.P. India**

**NAAC Accredited “A” Grade University
Established 1970**



**CBCS Syllabus of M.Sc. Botany
Session 2022-23 Onwards**

**Department of Bio-Sciences
Himachal Pradesh University, Shimla**

OUTLINE OF COURSES FOR M. Sc. BOTANY **Choice Based Credit System**

Course Code	Course Name	L+T+P	Credits
SEMESTER - I			
MBOT-101	Biology and Diversity of Algae and Fungi	3+1+0	4
MBOT-101 (P)	Biology and Diversity of Algae and Fungi - Practical	0+0+2	2
MBOT-102	Cell and Molecular Biology (Common with MZOO-102)	3+1+0	4
MBOT-102 (P)	Cell and Molecular Biology - Practical	0+0+2	2
MBOT-103	Biochemistry and Metabolism (Common Course with MZOO103)	3+1+0	4
MBOT-103 (P)	Biochemistry and Metabolism - Practical	0+0+2	2
MBOT-104	Tools and Techniques in Biological Sciences (Common with MZOO-104)	3+1+0	4
MBOT-104 (P)	Tools and Techniques in Biological Sciences - Practical	0+0+2	2
Total			24
SEMESTER - II			
MBOT-201	Biology and Diversity of Microbes and Plant Pathogens	3+1+0	4
MBOT 201-(P)	Biology and Diversity of Microbes and Plant Pathogens - Practical	0+0+2	2
MBOT-202	Ecology and Environment (Common with MZOO-202)	3+1+0	4
MBOT 202-(P)	Ecology and Environment - Practical	0+0+2	2
MBOT-203	Cytogenetics and Evolution (Common with MZOO-203)	3+1+0	4
MBOT 203-(P)	Cytogenetics and Evolution - Practical	0+0+2	2
MBOT-204	Biostatistics and Bioinformatics (Common with MZOO-204)	3+1+0	4
MBOT 204-(P)	Biostatistics and Bioinformatics - Practical	0+0+2	2
Total			24
SEMESTER – III			
MBOT-301	Biology and Diversity of Bryophytes and Pteridophytes	3+1+0	4
MBOT-301 (P)	Biology and Diversity of Bryophytes and Pteridophytes - Practical	0+0+2	2
MBOT-302	Plant Physiology	3+1+0	4
MBOT-302 (P)	Plant Physiology - Practical	0+0+2	2
MBOT-303	Biology and Diversity of Gymnosperms	3+1+0	4
MBOT-303 (P)	Biology and Diversity of Gymnosperms - Practical	0+0+2	2
MBOT-304	Plant Biotechnology		
MBOT-304 (P)	Plant Biotechnology - Practical		
MBOT-305	Plant Propagation Techniques		
MBOT-305 (P)	Plant Propagation Techniques - Practical		
Note: Select one Course of theory and one Course of practical out of MBOT-303, MBOT-304 and MBOT-305			
MBOT-306	Biology and Diversity of Angiosperms	3+1+0	4
MBOT-306 (P)	Biology and Diversity of Angiosperms - Practical	0+0+2	2
MBOT-307	Tissue Culture and Horticultural Sciences		
MBOT-307 (P)	Tissue Culture and Horticultural Sciences - Practical		
MBOT-308	Wood Science and Forest Biodiversity		
MBOT-308 (P)	Wood Science and Forest Biodiversity - Practical		
Note: Select one Course of theory and one Course of practical out of MBOT-306, MBOT-307 and MBOT-308			
Total			24

SEMESTER – IV			
MBOT-401	Anatomy, Palynology and Reproductive Biology of Angiosperms	3+1+0	4
MBOT-401 (P)	Anatomy, Palynology and Reproductive Biology of Angiosperms - Practical	0+0+2	2
MBOT-402	Plant Resource Utilization and Breeding	3+1+0	4
MBOT-402 (P)	Plant Resource Utilization and Breeding - Practical	0+0+2	2
Special Courses			
MBOT-403(i)	Advances in Mycology and Plant Pathology	3+1+0	4
MBOT-403(i) (P)	Advances in Mycology and Plant Pathology - Practical	0+0+2	2
MBOT-403(ii)	Advances in Applied Microbiology	3+1+0	4
MBOT-403(ii) (P)	Advances in Applied Microbiology - Practical	0+0+2	2
MBOT-404(i)	Ethnobotany and Biodiversity Conservation		
MBOT-404(ii) (P)	Ethnobotany and Biodiversity Conservation - Practical		
MBOT-404(i)	Ethnobotany, Bioprospecting and Traditional Knowledge		
MBOT-404(ii) (P)	Ethnobotany, Bioprospecting and Traditional Knowledge - Practical		
MBOT-405(i)	Advances in Plant Physiology and Biochemistry - I		
MBOT-405(ii) (P)	Advances in Plant Physiology and Biochemistry - I Practical		
MBOT-405(i)	Advances in Plant Physiology and Biochemistry - II		
MBOT-405(ii) (P)	Advances in Plant Physiology and Biochemistry - II Practical		
MBOT-406(i)	Phytochemistry and Palynology of Plant Kingdom - I		
MBOT-406(ii) (P)	Phytochemistry and Palynology of Plant Kingdom - I Practical		
MBOT-406(i)	Phytochemistry and Palynology of Plant Kingdom - II		
MBOT-406(ii) (P)	Phytochemistry and Palynology of Plant Kingdom - II Practical		
Note: Select one Specialization with two Courses of theory and two Courses of practical out of MBOT-403, MBOT-404, MBOT-405, MBOT-406			
MBOT-407	PROJECT (Assigned in the 3 rd Semester and goes until 4 th Semester)	4	4
Total			28
Total Credits (Semester I+II+III+IV = 24+24+24+28)			100

M.Sc. BOTANY

TWO YEAR FULL TIME PROGRAMME

AFFILIATION: The proposed programme shall be governed by the Department of Biosciences, Himachal Pradesh University, Summer Hill, Shimla H.P. 171005

PROGRAMME STRUCTURE:

The M.Sc. Programme is divided into two Parts as under. Each part will consist of Two Semesters as given below.

		Semester-Odd	Semester-Even
Part I	First Year	Semester – 1	Semester – 2
Part II	Second Year	Semester – 3	Semester – 4

Semesters I and II (Part I) shall have Core Courses to be studied by all students of the M.Sc. Botany programme. Semesters III and IV (Part II) would comprise Optional Courses from which each student would have to select the Courses from pool. In Semester IV there shall be specialization in which students has to opt one specialization out of total offered by the department and study two courses of that. Allotment of specialization shall be on the basis of merit/choice. It is mandatory for each student to complete a project, assigned in beginning of 3rd semester and goes on until 4th semester. It may be theoretical/field based and not involve any laboratory components.

SCHEME OF EXAMINATIONS

1. Examinations shall be conducted at the end of each semester as per the Academic Calendar/Date Sheet notified by the University.
2. The program description is as under:

(i)	Internal Assessment	40 marks
(a)	Term Exam I + Attendance	15+5 = 20 marks
(b)	Term Exam II + Attendance	15+5 = 20 marks
(ii)	End-Semester Examination	40 marks
(a)	Theory Examination	40 marks
(b)	Practical Examination (Execution-12, Viva-05, Record-03)	20 marks
	Grand Total	100 Marks

3. The system of evaluation shall be as follows:
 - 3.1 Internal assessment will be broadly based on attendance in Theory and Practicals (5

marks), assignments, seminars and tests in the theory component. These criteria are tentative and could be modified based on guidelines approved by the board of studies.

3.2 As regards project, the scheme of evaluation shall be as follows:

3.2.1 Project work would be assigned in the beginning of 3rd Semester to enable students to initiate work on the same.

3.2.2 It would formally begin from Semester III and shall be theoretical/field based in nature.

3.2.3 There shall be a viva-voce examination (conducted by a board of faculty members) at the end of Semester IV on the project work that shall be evaluated for 02 credits/50 marks.

4. Examinations for courses shall be conducted only in the respective odd and even Semesters as per the Scheme of Examinations.
5. The students have to attain 100% credits (100 credits) as mentioned in scheme to get master degree in Botany (M.Sc. Botany).
6. Code MBOT stands for M - Masters, BOT – Botany.

COURSE EVALUATION (Evaluation of the Students)

All courses (Core and Elective) involve an evaluation system of students that has the following two components:

- (i) Continuous Comprehensive Assessment (CCA) accounting for 50% of the final grade that a student gets in a course; and
 - (ii) End-Semester Examination (ESE) accounting for the remaining 50% of the final grade that the student gets in a course.
- (i) **Continuous Comprehensive Assessment (CCA)**: This would have the following components:
- (a) **Classroom Attendance** – Each student will have to attend a minimum of 75% Lectures/Tutorials /Practicals. A student having less than 75% attendance will not be allowed to appear in the End-Semester Examination (ESE).
 - Provided that those having between 74% and 65% attendance will apply for exemption in a prescribed form accompanied by clear reason(s) for absence to the authorized functionaries.
 - Provided that those having between 64% and 50% attendance will apply for exemption in a prescribed form accompanied by a Medical Certificate from a Government Hospital.
 - Provided that exemption from 75% attendance will be given to those participating in

prescribed co-curricular activities (e.g. NCC, NSS, Youth Festivals, Sports etc.) to the extent of 25% (making the necessary attendance as 50% in these cases). However, the claim for this exemption should be supported by authenticated certificate from the concerned college / University authorities.

- Provided further that those getting the exemptions, except for those getting exemptions for co-curricular activities, will not be entitled for getting the CCA marks for classroom attendance as given below.

Those having greater than 75% attendance (for those participating in Co-curricular activities, 25% will be added to per cent attendance) will be awarded CCA marks as follows:

> 75% but < 80%	1 marks
80% to 85%	2 marks
> 85 but < 90%	3 marks
90% to 95%	4 marks
> 95%	5 marks

- (ii) **Mid-Term (Minor) Tests:** There will be two mid-term tests, first after 40 teaching days (8 weeks) covering the syllabus covered so far, and second after 80 teaching days (16 weeks) covering the syllabus after the first minor test. Each of these mid-term tests will be for 15 marks.
- (iii) **Seminar/Assignment/Term Paper** – The remaining 15 marks of the CCA will be awarded on the basis of seminar / assignment / term paper etc. that the course teacher might give to the students. At least one such seminar / assignment / term paper will have to be done in a semester course.
- (iv) **End-Semester Examination (ESE):** The remaining 50% of the final grade of the student in a course will be on the basis of an end-semester examination (ESE) that will be for three hours duration and will be covering the whole syllabus of the course.

PROMOTION CRITERIA

SEMESTER TO SEMESTER: Students shall be required to fulfill the Part to Part Promotion Criteria. Within the same Part, students shall be allowed to be promoted from a Semester to the next Semester, provided she/he has passed at least half of the courses of the current semester.

PART I TO PART II: Admission to Part II of the programme shall be open to only those students who have successfully passed at least 75% papers out of papers offered for the Part I courses comprising of Semester-1 and Semester-2 taken together. However, she/he will have to clear the remaining papers while studying in Part-II of the programme.

NOTE: The theory course shall carry 40 teaching hours

SYLLABUS FOR M.Sc. BOTANY

Semester – I

Course: Biology and Diversity of Algae and Fungi

Course Code: MBOT-101

Credits (L+T+P): 3+1+0

Algae:

1. Algae in diversified habitats (terrestrial, fresh water, marine).
2. Thallus organization in algae.
3. Cell ultra-structure.
4. Reproduction (vegetative, asexual, sexual) and patterns of lifecycle.
5. Criteria for classification of algae (pigments, reserved food, flagella).
6. Fine structure of algal plastids.
7. Algal blooms.
8. Algal biofertilizers.
9. Economic importance of algae.
10. General account of lichens and their economic importance.

Suggested Reading:

- Fritsch, F.E. (1971-1972). The Structure and Reproduction of Algae. Vol. I & II, London, Cambridge Univ. Press.
- Kamat, N.D. (1982). Topics in Algae. Sai Kirpa Prakashan, Aurangabad.
- Kumar, H.D. (1988). Introductory Phycology. Affiliated East-West Press limited, New Delhi.
- Round, F.E (1986). The Biology of Algae. Cambridge University Press, Cambridge.
- Kumar, H.D. (1985). Algal Cell Biology. Affiliated East-West Press Limited, New Delhi.
- Moris. I. (1967). An Introduction to the Algae. Hutchinson University Library, London.

Fungi:

1. Introduction to Mycology: General characteristics, organization of fungal cell, thallus and modifications; cell wall composition; nutrition in fungi (saprophytes, parasites, predators, symbionts); reproduction (vegetative, asexual and sexual), recent trends in the classification of fungi and their significance to human.

2. Structural diversity and mode of reproduction in Dictyosteliomycota (*Dictyostelium*), Myxomycota (*Physarum*), Chytridiomycota (*Synchytrium*), Oomycota (*Saprolegnia*, *Pythium*, *Phytophthora*), Zygomycota (*Mucor*), Ascomycota (*Taphrina*, *Yeast*, *Neurospora*, *Claviceps*), Basidiomycota (*Ustilago*, *Puccinia*) and Deuteromycota (*Alternaria*, *Cercospora*, *Colletotrichum*, *Pyricularia*).
3. Sex hormones in fungi, heterothallism and parasexual cycle in fungi,
4. Importance of fungi in different microbiological and biotechnological processes, fungi in food and food industry, in agriculture, and as agents of biotransformation, biodegradation, biosorption and biomining.
5. Medical Mycology: General account on pathogenic fungi of human beings. Superficial, cutaneous, sub-cutaneous and systemic mycosis. Opportunistic mycosis - Candidiasis, Aspergillosis and Mucormycosis.

Note: The Question paper will be divided into two sections as follows: Section A: Algae and Section B: Fungi.

Suggested Books:

- Ainsworth, G.C., Sparrow, F.K. and Man, A.F.S. (1973). The Fungi - An Advanced Treatise. Academic Press.
- Alexopoulos, C.J. and Mims, C.W. Introductory Mycology, 3rd edition. Wiley-Easter, New Delhi.
- Alexopoulos, C.J., Mims, C.W. and Blackwell, M. (1996). Introductory Mycology. John Wiley and Sons.
- Deacon, J.W. Introduction to Modern Mycology. ELBS.
- Moore-Landerckar, E.J. (1972). Fundamentals of the Fungi. Prentice Hall, Englewood Cliffs.
- Burnett, H.L. Fundamentals of Mycology. Edward Arnold, London.
- Aneja, K.R. and Mehrotra, R.S. Introductory Mycology.
- Dube, H.C. An Introduction to Fungi. Vikas Publ. New Delhi.
- Gupta, R. and Mukerji, K.G. (2001). Microbial Technology. A.P.H. Publishing Corporation, New Delhi.
- Chander, J. (2018). Textbook of Medical Mycology (4thed.). Jaypee Brothers Medical Publishers.
- Beneke, E.S. and Roger, A.L. (1996). Medical Mycology and Human Mycoses. Star Pub Co.

- Dey, N.C., Grueber, H.L.E. and Dey, T.K. (2012). Medical Mycology. Central Book Agency.
- Kwon-Chung, K.J. and Bennett, J.E. (1992). Medical Mycology. Lea and Febiger, U.S.
- Razzaghi-Abyaneh, M., Shams-Ghahfarokhi, M. and Rai, M. (2015). Medical Mycology: Current Trends and Future Prospectus. CRC Press.

Course: Biology and Diversity of Algae and Fungi - Practical	
Course Code: MBOT-101 (P)	Credits (L+T+P): 0+0+2

Laboratory Exercises:

1. Algal collection from different habitats and their identification.
2. Morphological and reproductive stages of some genera of Cyanophyta, Chlorophyta, Xanthophyta, Pheophyta and Rhodophyta.
3. Learning the methods of sterilization and media preparation.
4. Learning the methods of test tube slant preparation and techniques of inoculation.
5. Inoculation of media by dilution plate method for the preparation culture of some local fungal flora.
6. Morphological studies and identification of the fungi through temporary and permanent mounts as mentioned in syllabus.

Course: Cell and Molecular Biology (Common with MZOO-102)	
Course Code: MBOT-102	Credits (L+T+P): 3+1+0

1. Structural Organization of Plant and Animal Cell:
 - i) Cell wall: structure, function and biogenesis.
 - ii) Plasma membrane; structure, models, functions, principles of membrane transport; types of carrier proteins and active membrane transport (Na^+ and K^+ pump, Ca^{++} pump, H^+ pump); Ion channels.
 - iii) Plasmodesmata: structure, role in movement of molecules, comparison with gap junctions, role and functions of cadherins and selectins.
 - iv) Plant vacuole: Tonoplast membrane, ATPases storage organelle.

- v) Structure and functions of micro bodies: Golgi apparatus, lysosomes, endoplasmic reticulum. Transport from ER to Golgi and then to lysosomes; Molecular basis of endocytosis and exocytosis.
2. Chloroplast and mitochondria: Structure, genome organization, gene expression, nucleochloroplastic interactions, biogenesis of mitochondria.
 3. Nucleus: structure, nuclear pores, nucleosome organization, nucleolus.
 4. The cytoskeleton: Organization and role of microtubules and microfilaments, motor movements implications in flagellar and other movements.
 5. Cell cycle and apoptosis: Control mechanisms, role of cyclins, cyclin-dependent kinases, cytokinesis and cell plate formation, mechanisms of programmed cell death and its regulation.
 6. Cell signaling through: protein tyrosine kinase receptors, JAK-STAT, cAMP, MAP kinase, NF-kB signaling pathways; insulin and Integrin signaling.
 7. Cancer (progenitor cells, oncogenes, tumor suppressor genes) and therapeutic interventions of uncontrolled cell growth.
 8. Gene expression:
 - i) Structure and types of DNA; replication, DNA damage and repair.
 - ii) Transcription, promoters and transcription factors, splicing, mRNA transport, rRNA biosynthesis, differences in prokaryotes and eukaryotes.
 - iii) RNA splicing: Nuclear splicing, spliceosome and small nuclear RNAs.
 - iv) Translation; structure of ribosome, mechanism of translation initiation, elongation and termination, structure and role of tRNA.
 9. Regulation of gene expression in prokaryotes (Run off transcription, Britten-Davidson and Mated models of gene regulation) and eukaryotes.
 10. Protein sorting: Targeting of proteins to organelles.

Suggested Readings:

- Alberts, B. (2008). Molecular Biology of the Cell. Garland Science.
- Alberts, B. Bray, D., Lewis, J. Raff, M., Roberts, K. and Watson, J.D. 1999, Molecular biology of the cell. Garland Publishing, Inc. New York.
- Benjamin Lewin (2000) Genes VII. Oxford Univ. Press, Oxford.
- Berg, J.M., Tymoczko, J.L., & Stryer, L. (2002). Biochemistry, Fifth Edition. W.H. Freeman.
- Berridge, M.J. (2014) Cell Signaling Biology. Portland Press.

- Bradshaw, R. A. and Dennis, E. A. (2003) Handbook of Cell Signaling. Vol. I, II and III. Academic Press.
- Cooper, G. M., & Hausman, R. E. (2004). The Cell: A Molecular Approach. ASM Press.
- Cooper, G.M. and Hausman, R.E. (2009) The Cell: A Molecular Approach. 5 th edition. ASM Press & Sunderland, Washington, D.C.; Sinauer Associates, MA.
- De Robertis, E.D.P. and De Robertis, E.M.F. (2006) Cell and Molecular Biology. 8th edition. Lippincott Williams and Wilkins, Philadelphia.
- Frifelder, D. Molecular Biology. John and Bartlett Publishers, inc., Boston, USA.
- J. D. Watson, T. A. Baker, S. P. Bell, A. Gann, M. Levine, R. Losick (2004) Molecular Biology of the Gene, 5th edn. Pearson Education Inc.
- Karp, G. (2013) Cell and Molecular Biology: Concepts and Experiments. 7th edition. John Wiley & Sons. Inc.
- Lewin, B. 2000. Genes VII Oxford University, Press, New York.
- Lodish, H. (2008). Molecular Cell Biology. W. H. Freeman.
- R. Basega. Cell Growth and Division. A Practical Approach., IRL Press, Oxford University.
- Strachan T and Read AP (2004) Human Molecular Genetics, Garland Science.
- Wolfe, S.L. 1993, Gruissem, W. and Jones, R.L. 2000, Biochemistry and molecular biology of plants, American society of plant physiologists, Maryland, USA

Course: Cell and Molecular Biology - Practical	
Course Code: MBOT-102 (P)	Credits (L+T+P): 0+0+2

Laboratory Exercise:

1. Microscopy: Bright field, phase contrast and Fluorescence microscopy.
2. Cell Isolation (plants and Animals), Microscopy and Micrometry: Fixed and live-cell imaging, Radioisotopes, Fluorescent Probes/Dyes as tools to study cellular functions, basics of FACS.
3. Determining cell number using hemocytometer.
4. Determining cell viability using Trypan blue staining and other cytotoxicity assays such as MTT assay, Alamar blue assay, LDH assay.
5. Discuss methods used to transfect mammalian cells. Transfect cells with green fluorescent protein and visualize cells under the fluorescence microscope.

6. Distribution of mammalian cells in different phases of cell cycle using flow cytometer.
7. To study the chromosomes of different stages of mitosis (Onion root tip) and meiosis (Flower buds).
8. Blood smear preparation and its analysis.
9. Identifying apoptotic and necrotic cells by the cell staining procedure.
10. Isolation of RNA from Blood/yeast.
11. Plant DNA extraction using standard protocols
12. Staining methods: Simple, negative, Acid fast, Gram staining, spore staining, capsule staining, lactophenol cotton blue staining.

Recommended texts

- Celis, J. E. (1997) Cell Biology: A Laboratory Handbook. 2nd edition. Academic Press.
- Cooper, Geoffrey M., and Robert E. Hausman. 2009. The cell: a molecular approach. Washington, D.C.: ASM Press.

Course: Biochemistry and Metabolism (Common with MZOO-103)	
Course Code: MBOT-103	Credits (L+T+P): 3+1+0

Biomolecules

Carbohydrates - Monosacharides, disacharides and polysaccharides.

Proteins - Classification and structure, Amino acids classification and general characters.

Lipids - classification and functions of lipids and fatty acids.

Nucleic acids - purines, pyrimidines, nucleotides, structure of DNA and RNA and types of RNA.

Biosynthesis and degradation of purines and pyrimidines.

Enzymes

Nomenclature and classification of enzymes, vitamins as co-enzymes.

Enzyme Kinetics - Michales –Menten equation. Determination of Vmax and Km, Factors affecting the enzyme activity.

Enzyme inhibition - Competitive and non-competitive.

Mechanism of enzyme action - active sites, Chymotrypsin as a model, Regulation of enzyme activity, allosteric enzymes, PFK, ATC (Phosphofructokinase /Aspartate trans carbamylase)

Bioenergetics

Basic Principles of thermodynamics free energy, Enthalpy and Entropy.

Redox Potential and electron transport.

ATP- Production (Chemiosmotic model), high energy phosphates, Coupled reactions.

Metabolism

Carbohydrate metabolism - Glycolysis, Krebs cycle, pentose Phosphate pathway.

Glycogenesis, Glycogenolysis, Gluconeogenesis, hexomonophosphate shunt.

Protein metabolism - Transamination and deamination, incorporation of amino acids into TCA cycle, integration between urea cycle and TCA cycle.

Lipid metabolism – fatty acid oxidation and biosynthesis, ketone bodies.

Metabolic defects of carbohydrate and amino acid metabolism.

Secondary Metabolites

Biosynthesis and function of secondary metabolites phenolics, flavonoids, terpenoids, alkaloids, steroids.

Importance of Acetyl Co. A and Shikimic acid in intermediary metabolism.

Suggested Reading:

- Zubay, G. (1988), Biochemistry (2nded.). MacMillan Publ. House New York.
- Mahler, H.R. and Codes E.H. (1971). Biological Chemistry. Harper International.
- Lehinger, A.I. (1978). Biochemistry. Kalyani Publishers, Ludhiana.
- Goodwin, T.W. and Mercer E.I. (1989). Introductory Plant Biochemistry. Pergamon Press, New York.
- Conn, E.E. and Stumpf. P.K. (1976). Outlines of Biochemistry. Wiley Eastern.
- Berg, J.M., Tymoczko, J.L., Stryer, L. (2002). Biochemistry (5thed.). W.H. freeman and Co. Ltd.
- Freifelder, Molecular biochemistry.

Course: Biochemistry and Metabolism - Practical

Course Code: MBOT-103 (P)

Credits (L+T+P): 0+0+2

Laboratory Exercises:

1. To perform qualitative test for analysis of carbohydrates.
2. To determine titrimetrically the reducing sugar content in a given solution.

3. To determine glucose content in given solution spectrophotometrically.
4. To determine the saponification value of given fats and oils.
5. To determine acid number in a given fat or oil by titrimetrically.
6. To perform qualitative test for amino acid and proteins.
7. To determine the amount of phenol in given solution.
8. To determine the protein content by Lowry's method.
9. To study the action of acid and alkali on starch.

**Course: Tools and Techniques in Biological Sciences
(Common with MZOO-104)**

Course Code: MBOT-104

Credits (L+T+P): 3+1+0

Instrumentation

Centrifugation: Principle and applications of Centrifugation; differential and density gradient Centrifugation.

Electrophoresis: Principle, structural components and applications of electrophoresis.

Chromatography: Principle and applications of chromatography; adsorption, Ion exchange, gel permeation and affinity.

Spectrophotometer: Principle, pH meter and applications of Spectrophotometer.

Microscopy and Histological Techniques

Microscopy: Principle, and applications of different types of microscopes Light, Phase Contrast, SEM and TEM.

Microtome: Types and applications. Collection and preservation of animal tissue - fixation, embedding, Sectioning, Staining, Identification of different components.

Tissue preparation for light microscopy.

Cryotechniques: History and applications of Cryotechniques, cryopreservation of cells, tissue, organisms.

Cell Culture Techniques

Cell Culture System and History of development of cell culture.

Culture media preparation and cell harvesting methods.

Commonly used Cell Lines and their Uses.

Design and functioning of tissue culture laboratory.

Radiolabeling Techniques and Methods in Field Biology

Detection and measurement of different types of radioisotopes normally used in biology.

Molecular imaging of radioactive material.

Methods of estimating population density of animals and plants, ranging patterns through direct, indirect and remote observations

Sampling methods in the study of behavior, habitat characterization: ground and remote sensing methods.

Suggested Readings:

- Principles and Techniques in biochemistry and molecular biology - Wilson and Walkes.
- Culture of animal cells - Freshuay.
- Sharma V.K. (1991), Techniques in microscopy and cell Virology. Tata McGraw Hill.
- Robert Braun Introduction to instrumental analysis - Tata McGraw Hill.
- Bisen and Mathw. Tools and Techniques in Life Sciences - CBS Publishers and distributors.
- Principles of Animal Cell Culture (2008). Basant Kumar and Rinesh Kumar, Int. Bork 22nded.

Course: Tools and Techniques in Biological Sciences – Practical	
Course Code: MBOT-104 (P)	Credits (L+T+P): 0+0+2

Laboratory Exercises:

1. Separation of cell organelles by differential centrifugation.
2. Separation of protein by electrophoresis (Native and SDS page).
3. Separation of amino acids etc. by paper and thin layer chromatography
4. Demonstration of column Chromatography.
5. Validation of Beer-lamberts law of a colored compound (CuSO₄).
6. Measurement of pH meter and preparation of buffer.
7. Light microscope and its parts observation of unstained and stained cells.
8. Demonstration of a fixation, dehydration, sectored and stand of any animal tissue.
9. Demonstration of carbohydrates, proteins lipids and nuclear acids in tissue sections.
10. Preparation of chick fibroblast culture and viability testing.

Semester – II

Course: Biology and Diversity of Microbes and Plant Pathogens	
Course Code: MBOT-201	Credits (L+T+P): 3+1+0

Microbes:

1. History and scope of microbiology, landmarks in microbiology, major groups of microorganism, characterization, identification and classification of microorganism.
2. Structure of Bacteria: Ultra structure of bacterial cell and cell wall. Nutrition of bacteria: modes of nutrition, nutritional types, growth characteristics, reproduction and genetic recombination: binary fission, resting structure, conjugation, transformation and transduction; mechanism of antibacterial action.
3. Virus: History, structure and classification, plant and animal viruses, nature and transmission, genome organization (TMV, CMV, CAMV and Gemini viruses), isolation and purification, detection, identification and economic importance; bacteriophages, viroids and prions nature and importance, viruses in cancer.
4. Principles of immunology: general account of immunity, allergy, antigen- antibody, serology and types of vaccines.
5. Applications of microbes in agriculture (Biofertilizers, biopesticides), industry (alcoholic beverages, citric acid, penicillin production), environment (pollution indicator and control), and genetic engineering.

Suggested Reading:

- Stanier, R.Y. (1970). General Microbiology MacMillan.
- Pelezar, M.J., Reid, R.D. and Chan, E.C.S. (1977). Microbiology, Tata McGraw Hill.
- Kumar, H.D and Rai, D.C. (1990). Microbes and Microbial Processes. East West.
- Ketchum, P.A. (1980). Microbiology - Concepts and Applications Wiley, New York.
- Tauro, P., Kapoor, K.K. and Yadav, K.S. (1996). An Introduction to Microbiology. Wiley Eastern Ltd.
- Schlegel, H.G. (1996). General Microbiology. Cambridge University Press.
- Gupta, R. and Mukerji, K.G. (2001) Microbial Technology. A.P.H. Publishing Corporation, New Delhi.

- Tortora, G.J. Funke, B.R. and Case, C.L. Microbiology - An Introduction. Addison Wesley Longman, Inc. California.

Plant Pathogens:

1. History of plant pathogens, concept, diagnoses, classification, importance and identification of unknown diseases; symptomology and disease development.
2. Host- pathogen interaction at plant and cellular level: Mechanism of pathogen attack and defense: Physical, physiological, biochemical and molecular aspects.
3. Host pathogen interaction at population level: Transmission and spread of plant pathogens, disease epidemics, modeling and disease forecasting to control crop losses.
4. Management of plant disease: Chemical, Biological, IPM system, development of transgenics, biopesticides and quarantine.
5. Genetics of plant disease: Gene for virulence and avirulence. Their application in resistance and susceptibility, induced resistance (immunization).
6. Specific plant diseases caused by diverse pathogens: Black wart disease of potato, late blight of potato, downy mildew of grapes and bajra, peach leaf curl, powdery mildew of wheat and apple, apple scab, general account of rusts, smut and bunts, fusarial wilt of tomato, rhizome rot of ginger, tikka disease of groundnut, red rot of sugarcane, brown leaf spot and blast of rice. Bacterial blight bean, common scab of potato, fire blight of apple, citrus canker, tobacco mosaic virus.

Note: The Question paper will be divided into two sections as follows: Section A: Microbes and Section B: Plant Pathogens.

Suggested Books:

- Agrios, G.N. (1988). Plant Pathology, Academic Press.
- Butler, E.J and Jones, S.G. (1986). Plant Pathology, Periodical Expert Book Agency Delhi.
- Mehrotra, R.S. Plant Pathology. Tata McGraw Hill, Publishing Company, New Delhi.
- Bilgrami, K.S. and Dubey, H.C. (1980). Text Book of Modern Plant Pathology. Vikas, New Delhi.
- Mundkar, B.B. (1967). Fungi and Plant Diseases. McMillan.
- Wood, R.K.S. (1967). Physiological Plant Pathology. Blackwell Scientific Publications.
- Tarr, S.A.J (1972). Principles of Plant Pathology. McMillan.
- Horsfall, J.G. and Dimond, E. Plant Pathology. Academic Press, New York.

- Horsfall, J.G. and Cowling, E.B. Plant Disease Vol. I-V. Academic Press, New York.

Course: Biology and Diversity of Microbes and Plant Pathogens - Practical	
Course Code: MBOT-201 (P)	Credits (L+T+P): 0+0+2

Laboratory Exercises:

1. To study bacteria by using Gram's staining method.
2. Demonstration of the presence of nitrogen fixing organisms (*Rhizobium* sp.) and their isolation from root nodules of legumes.
3. Learning the methods of sterilization, media preparation and inoculation techniques.
4. Isolation of plant pathogens from infected tissue by tissue segment method.
5. Symptoms and etiology of plant diseases as mentioned in syllabus through specimens, temporary and permanent mounts.

Course – XIV: Ecology and Environment (Common with MZOO-202)	
Course Code: MBOT-202	Credits (L+T+P): 3+1+0

1. Ecosystem organization: Life zones, major biomes, concepts of community, ecological succession, structure and functions of ecosystem, primary production, energy dynamics, litter fall, arid decomposition, global biogeochemical cycles, minerals cycles in terrestrial and aquatic ecosystems.
2. Population growth and dynamics: Models of population growth (Stochastic and time lag), reproduction strategies, mating preference, spacing system, r and k selection, case studies in population dynamics.
3. Predation: Predators-Prey interaction, host parasite interaction, role of predation in nature.
4. Competition and mutualism: Types and theories of competition, commensalism and mutualism, plant - pollinator and animal - animal interactions. Niche theory.
5. Biological diversity: Concepts and levels, role of biodiversity in ecosystem functions and stability, speciation and extinction, IUCN, categories of threat, distribution and global patterns, terrestrial biodiversity hotspots.
6. Environmental pollution: Types, sources, effects on plant and animal ecosystems, greenhouse

gases, ozone layer and ozone hole, consequences of climatic change.

7. Ecological management: Concepts, sustainable development, sustainability indicators, degraded ecosystem and their regeneration with special reference to waste lands, forests and aquatic ecosystems.

Suggested Reading:

- Begon and Mortimer, Population Ecology.
- Horace and Quick, Population Ecology.
- Elseth, G.D., Population Biology.
- Thomas, C. E., Population Biology.
- Kerbs, C.J., Ecology.
- Kerbs, C.J., Ecological Methodology.
- Slanden and Bang, Biology of populations.
- Hillary, S.E. Ecology 2000.
- Merritt Emlen, J., An Evolutionary Approach
- Brewer, Principles of Ecology.
- Price, P.W., Slobodchikoff, and Gand, W.S., A New Ecology.
- Odum, Fundamentals of Ecology.
- H.D. Kumar. General Ecology- 1997
- J. Merritt Emlen, Ecology –1973

Course: Ecology and Environment – Practical	
Course Code: MBOT-202 (P)	Credits (L+T+P): 0+0+2

Laboratory Exercises:

1. To determine the minimum size of quadrat by species area curve method.
2. To collect plant and animal species and get them identified.
3. To measure the temperature of soil at different depths.
4. To study the biotic component of pond ecosystem or man-made ecosystem.
5. To determine the water holding capacity of different soil (Sandy, loamy and clay soil)
6. To study the physio-chemical properties of given soil sample and find: i) Moisture content ii)

Bulk density iii) soil porosity.

7. To study community by quadrat method and determine relative frequency, relative density, relative dominance, abundance, and IVI value of different species.
8. To determine the biomass of a given area.
9. To confirm the presence of carbonate, nitrate and pH in the given soil samples.
10. To compare the percentage humus content in the given soil samples.
11. To determine the CO₂ level in the different water samples.

Course: Cytogenetics and Evolution (Common with ZOO203)	
Course Code: MBOT-203	Credits (L+T+P): 3+1+0

1. Chromosome organization:

- i) Structure of chromosomes, DNA packaging and DNA replication
- ii) Metaphase chromosomes, centromere, kinetochore, telomere and its importance
- iii) Heterochromatin and euchromatin
- iv) Chromosome banding
- v) Polytene and lampbrush chromosomes

2. Sex chromosomes, sex determination and dosage compensation in *Drosophila* and human

3. Mendelian and Non-Mendelian inheritance:

- i) Mendelian inheritance and its modification
- ii) Maternal effect
- iii) Epigenetic inheritance
- iv) Extra nuclear inheritance

4. Variation in chromosome structure and number

5. Brief description of gene expression:

- i) Genetic code
- ii) Transcription and translation
- iii) Regulation of gene expression

6. Gene mutation and DNA repair:

- i) Consequences of mutations
- ii) Occurrence and causes of gene mutation

iii) DNA repair

7. Quantitative genetics:

i) Quantitative traits

ii) Polygenic inheritance

iii) Heritability

8. Population genetics and evolution:

i) Genes in populations

ii) The Hardy-Weinberg Equilibrium

iii) Factors that change allele frequencies in populations.

iv) Origin and evolution of species

v) Biological species concept

vi) Anagenesis and cladogenesis

vii) Allopatric, parapatric and sympatric speciation

viii) Gradualism and punctuated equilibrium

ix) Neo-Darwinism

9. Molecular evolution

i) Experimental approaches used to compare species at molecular level

ii) Phylogenetic trees

iii) Molecular drive-a cohesive mode of species evolution

iv) Neutral theory of molecular evolution

Suggested Readings:

- Gardener, E.J., Simmon, M.J. and Snustad, D.P. Principles of Genetics. John Wiley and Sons, Inc. NY.
- Weaver, R.F. and Hedrick, P.W. Genetics. William. C. Brown Publishers.
- Brown, T.A. Genetics- A Molecular Approach. Chapman and Hall.
- Mitra, S. Genetics- A Blueprint of Life. Tata McGraw Hill.
- Dobzhansky, T. Genetics and Origin of Species. Columbia University Press.
- Futuyama, D.J. Evolutionary Biology. Sinauer Associates. Sunderland.
- King, M. Species Evolution - The Role of Chromosomal Change. The Cambridge University Press, Cambridge.

- Merrel, D.J. Evolution and Genetics. Holt, Rinehart and Winston, Inc.
- Strickberger, M.W. Evolution. Jones and Bartlett Publishers. Boston London.

Course: Cytogenetics and Evolution - Practical	
Course Code: MBOT-203 (P)	Credits (L+T+P): 0+0+2

Laboratory Exercises:

1. To study the various stages of mitosis in onion root tips.
2. To study the mitosis in the colchicine treated onion root tips.
3. To study the various stages of the meiosis in floral buds of onion to determine the mitotic division.
4. To study the multiple alleles or blood group in human.
5. To prepare the slides of salivary gland chromosomes of *Drosophila* larva.
6. To study the multiple alleles in *Trifolium* spp. leaves.
7. To study nuclear inheritance and cytoplasmic inheritance in the given plant material.
8. To study laws of probability by tossing single coins.
9. To study laws of probability by tossing two coins.
10. To study xenia and metaxenia in maize cob.
11. To study human traits and to find frequencies of hereditary characters.

Course: Biostatistics and Bioinformatics (Common with ZOO-204)	
Course Code: MBOT-204	Credits (L+T+P): 3+1+0

Introduction to Biostatistics

Definition and scope

Probability, Discrete and continuous variables, Presentation of Data.

Measures of central tendency: Mean, median, mode

Standard deviation

Biostatistics Software

Analysis of variance, Correlation and regression

Sampling: techniques, Errors, Framing Hypothesis, Level of Significance

Hypothesis testing

Student's t test, Chi Square test

Introduction to Bioinformatics

Introduction to bioinformatics, genomics and proteomics databases

Nucleic acid sequence database

Genbank, UCSC, ENSEMBL, EMBL, DDBJ, protein sequence databases: Swiss- PROT, PDB, BLAST, BLAST vs FASTA

Bioinformatics and drug discovery

Introduction to computational genomics and proteomics

Suggested Reading:

1. Gupta, S.C. (2018). Fundamentals of Statistics. Himalaya Publishing House.
2. Behera, S.R. (2019). Computer Application. B.K. Publications Pvt. Ltd.
3. Lesk, M. (2014) Introduction to bioinformatics. 4th ed. Oxford University Press
4. Krawetz, S.A. and Womble, D.D. (2003) Introduction to Bioinformatics. Humana Press.
5. Ghosh, Z. and Mallick, B. (2008). Bioinformatics: Principles and Application OUP India; Illustrated edition.
6. Mount, D.W. (2005). Bioinformatics sequence and genome analysis 2nd ed. CBS.

Course: Biostatistics and Bioinformatics - Practical	
Course Code: MBOT-204 (P)	Credits (L+T+P): 0+0+2

Laboratory Exercises:

1. Based on the theory syllabus

Semester – III

Course: Biology and Diversity of Bryophytes and Pteridophytes

Course Code: MBOT-301

Credits (L+T+P): 3+1+0

Bryophytes:

1. General introduction and salient features of Bryophytes. Comparison among Cryptogamous plants.
2. Classification of Bryophytes into Liverworts, Hornworts and Mosses.
3. A general account of Marchantiales, Jungermanniales, Anthocerotales, Sphagnales, Funariales and Polytrichales (emphasis is not to be placed on families or type studies).
4. A general account of Peristome in Mosses.
5. Primitive versus advanced/derived feature and evolutionary lines within Bryophytes.
6. Morphogenesis in Bryophytes.
7. Distribution and ecology of Bryophytes in India with particular reference to Himachal Pradesh.
8. Ecological and economic importance of Bryophytes.

Suggested Readings:

- Cavers, F. (1911). The Inter-relationship of Bryophyta. New Phytology Reprint No. 4:1-203.
- Chopra, R.S. (1976). Inter-relationship of Indian Bryophytes. The Chronica Botanica, New Delhi.
- Chopra, R.S and Kumar, S.S. (1976). Musci of the Western Himalayas and the Punjab Plains. The Chronic Botanica, New Delhi.
- Parihar, N.S. (1972). An Introduction to Embryophyta Vol. I. Bryophyta. Central Book Depot, Allahabad.
- Puri, P. (1981). Bryophytes: Morphology, Growth and differentiation. Atma Ram and Sons, Delhi and Lucknow.
- Rashid, A. (1998). An Introduction to Bryophyta (Diversity, Development and Differentiation). Vikas Publishing House Pvt. Ltd., New Delhi. 298pp.
- Udar, R. (1976). Bryology in India. The Chronica Botanica, New Delhi.
- Watson, E.V. 1971. The Structure and life of Bryophytes. Hutchinson University Library, London.

Pteridophytes:

1. General introduction and salient features of Pteridophytes, comparison among archegoniatae.
2. Classification of Pteridophytes.
3. A general account of the following fossil Pteridophytes: *Rhynia*, *Horneophyton*, *Asteroxylon*, *Lepidodendron*, *Pleuromeia*, *Sphenophyllum*, *Calamites* and *Osmundites*.
4. Salient feature of Psilopsida, Lycopsida, Sphenopsida and Pteropsida (Emphasis is not to be placed on orders, families or types studies).
5. Structure and evolution of Stelar System in Pteridophytes.
6. Telome theory or the evolution of sporophyte in Pteridophytes.
7. Natural and induced implications of Apogamy and Apospory in Pteridophytes.
8. Heterospory and seed habit in Pteridophytes.
9. Distribution and ecology of the Ferns of the Himalaya with particular reference to Himachal Pradesh.
10. Cytological evolution in Pteridophytes.
11. Economic importance of Pteridophytes.

Note: The Question paper will be divided into two sections as follows: Section A: Bryophytes and Section B: Pteridophytes.

Suggested Reading:

- Andrews, H.N. (1961). Studies in Palaeobotany. John Wiley and Sons, Inc, New York and London.
- Khullar, S.P. (1994). An Illustrated Fern Flora of West Himalaya Vol. I. International Book Distributors, Dehradun, India. 506 pp.
- Khullar, S.P. (2000). An Illustrated Fern Flora of West Himalaya Vol. II. International Book Bistributors, Dehradun, India. 538pp.
- Parihar, N.S. (1996). The Biology and Morphology of Pteridophytes. Central Book Depot, Allahabad. 777pp.
- Rashid, A.R. (1999). Introduction to Pteridophyta- Diversity, Development and Differentiation. 2nd Revised Edition. Vikas Publishing Co., New Delhi.426pp.
- Seth, M.K., Kumari, A., Thakur. R. and Khullar, S.P. (2002). Pictorial Guide to Common Himalayan Pteridophytes Vol. I. Pteridophytes of Shimla.
- Sharma, O.P. (1990). Text Book of Pteridophytes. McMillan India Ltd., New Delhi. 360 pp.

- Smith, G.M. (1971). Cryptogamic Botany Vol. II. Bryophytes and Pteridophytes. Tata McGraw Hill Publishing Co., New Delhi. 546 pp.
- Sporne, K.R. (1982). The Morphology of Pteridophytes. Hutchinson University Library, London (Reprinted in 1991 by B.I. Publishing Pvt. Ltd., Bombay).
- Stewart, W.N. and Rothwell, G.W. (1993). Palaeobotany and the Evolution of Plants. Cambridge University Press, London.

Course: Biology and Diversity of Bryophytes and Pteridophytes - Practical	
Course Code: MBOT-301 (P)	Credits (L+T+P): 0+0+2

Laboratory Exercises:

1. Field trips to familiarize with natural habitats, growth forms and diversity of Bryophytes.
2. Study of morphological and anatomical details of vegetative and reproductive structures of the Bryophytes as mentioned in the syllabus through specimens, temporary and permanent slides.
3. Field trips to familiarize with natural habitats, growth forms and diversity of Pteridophytes.
4. Study of morphological and anatomical details of vegetative and reproductive structures of the Pteridophytes as mentioned in the syllabus through specimens, temporary and permanent slides.
5. Perform the differential staining and prepare the permanent slides of Pteridophytes.
6. Study of important fossil Pteridophytes from permanent slides.

Course: Plant Physiology	
Course Code: MBOT-302	Credits (L+T+P): 3+1+0

1. Plant-water relations, transport of solutes: Physicochemical properties of water, water potential, apparent free space, bulk movement of water, SPAC, passive and active solute transport.
2. Stomatal physiology: Chemiosmotic mechanism of stomatal movements, hormonal regulation and significance of calcium ions.
3. Photochemistry and Photosynthesis: General concepts and historical background, evolution of photosynthetic apparatus, photosynthetic pigments and light harvesting complexes, Photooxidation of water, mechanism of electron and proton transport. Carbon assimilation: The

calvin cycle, photorespiration and its significance, C₄ cycle, CAM pathways, biosynthesis of starch and sucrose, physiological and ecological considerations.

4. Respiration: Overview of plant respiration, glycolysis, TCA cycle, electron transport and ATP synthesis, structure and functions of ATP, pentose phosphate pathways, glyoxylate cycle, alternative oxidase system.
5. Nitrogen fixation, nitrogen and sulphur metabolism: Overview, biological nitrogen fixation, nodule formation and nod factors, mechanism of nitrate uptake and reduction, ammonium assimilation, sulphate uptake, transport and assimilation.
6. Sensory photobiology: History of discovery of phytochromes and cryptochromes, their photochemical and biochemical properties, photobiology of light-induced responses.
7. Plant growth regulators and elicitors: Physiological effects and mechanism of action of auxins, gibberellins, cytokinins, ethylene, abscisic acid.
8. The flowering process: Photoperiodism and its significance, endogenous clock and its regulation, floral induction and development, role of vernalization.

Suggested Reading:

- Buchanan, B.B. Gruissem, W. and Jones R.L. (2000). Biochemistry and Molecular Biology of Plants. American society of Plant Physiologists, Maryland, USA.
- Goodwin, T.W. and Mercer, L.E. (1989). Introductory Plant Biochemistry. Pergamon Press, New York, USA.
- Moore, T.C. (1989). Biochemistry and Physiology of Plants Hormones (2nd edition). Springer Verlag, New York, USA.
- Salisbury, F.B. and Ross, C.W. (1992). Plant Physiology (4th edition). Wadsworth Publishing Company, California, USA.
- Taiz, I. and Zeiger, E. (1998). Plant Physiology (2nd edition). Sinauer Associates Inc. Publishers, Massachusetts, USA.
- Wilkins, M.B. (ed.) (1984). Advanced Plant Physiology. ELBS, Longman, UK.

Course: Plant Physiology - Practical	
Course Code: MBOT-302 (P)	Credits (L+T+P): 0+0+2

Laboratory Exercises:

1. To determine the water potential (ψ) of the given tissue sample by weighing method.
2. To determine the water potential of the given tissue by plasmolytic method.
3. To determine the water potential of the given tissue by hanging drop method.
4. To determine the stomatal index in the given leaves for adaxial and abaxial surface.
5. To determine the effect of dark, k^+ concentration and ABA on stomatal movement.
6. To assay the α -amylase activity in germinating wheat seeds.
7. To separate the chloroplastic pigments by differential solubility method.
8. To compare and determine the activity of enzyme catalase in given tissue.
9. To assay the dehydrogenase activity in excised embryos from germinating bean seeds.
10. To determine the surface tension of given liquids.
11. To determine the phenomenon of electrical absorption.
12. To determine the chlorophyll contents in given Leaves.

Course: Biology and Diversity of Gymnosperms	
Course Code: MBOT-303	Credits (L+T+P): 3+1+0

1. General introduction, classification and salient features of Gymnosperms.
2. Comparison among Tracheophyta.
3. A general account of the following fossils Cycadopsida: *Lyginopteris*, *Crossotheca*, *Medullosa*, *Aulotheca*, *Dolerotheca*, *Calamopitys*, *Glossopteris*, *Caytonia*, *Williamsonia*, *Cycadeoidea*, and *Pentoxylon*.
4. A general account of following fossil Coniferopsida: *Eristophyton*, *Mesoxylon* and *Cordaites*.
5. Salient features of living Cycadales, Coniferales (including *Taxus*) and Ginkgoales (Emphasis is not to be placed on families or type studies.)
6. A general account of Ephedrales, Welwitschiales and Gnetales.
7. Distribution of Conifers in India with particular reference to Himachal Pradesh.

8. Economic importance of Gymnosperms.
9. Structure, properties and uses of the following commercial timbers: Blue Pine, Chir Pine, Deodar, Cypress and Yew.
10. Comparative account of the leaf anatomy of the living Gymnosperms.
11. Comparative study of male cones of living Gymnosperms.
12. Pollination mechanism in living Gymnosperms.
13. Comparative study of female cones of living Gymnosperms.
14. Comparative study of male gametophytes of living Gymnosperms.
15. Comparative study of female gametophytes of living Gymnosperms.
16. Structure and evolution of archegonium in Gymnosperms.
17. Embryogeny in Gymnosperms.

Suggested Readings:

- Andrew, H.N. (1961). Studies in Palaeobotany. John Wiley and Sons, Inc. New York and London.
- Biswas, C. and Johri, B.M. (1997). The Gymnosperms. Narosa Publishing House, New Delhi. 494 pp.
- Bhatnagar, S.P. and Moitra, A. (1996). Gymnosperms. New Age International Pvt. Ltd., New Delhi. 470 pp.
- Chamberlain, C.J. (1934). Gymnosperms Structure and Evolution. Chicago (Reprinted 1957, New York).
- Coulter, J.M. and Chamberlain, C.J. (1917). Morphology of Gymnosperms. Chicago (Reprinted 1974, Central Book Depot. Allahabad).
- Datta, S.C. (1966). An Introduction to Gymnosperms. Asia Publishing House, Bombay.
- Kakkar, R.K. and Kakkar, B.R. (1995). The Gymnosperms (Fossils and Living). Central Publishing House, Allahabad. 777 pp.
- Mehra, P.N. (1998). Indian Conifers, Gnetophytes and Phylogeny of Gymnosperms. Raj Bandhu Industrial Co., New Delhi. 264 pp.
- Raizada, M.B. and Sahni, K.C. (1960). Living Indian Gymnosperms Part - I (Cycadales, Ginkgoales and Coniferales). Indian Forest Records. N.S. Botany 5: i-iv, 73-150, Forest Research Institute, Dehradun.
- Sahni, K.C. (1990). Gymnosperms of India and Adjacent countries. Bishen Singh Mahendra Pal

Singh, Dehradun, 169 pp.

- Singh, H. (1978). Encyclopedia of Plant Anatomy Part X Embryology of Gymnosperms. Gebruder Borntraeger, Berlin, Stuttgart.
- Sporne, K.R. (1965). The Morphology of Gymnosperms. Hutchinson and Co. (Publishers) Ltd., London.

Course: Biology and Diversity of Gymnosperms - Practical	
Course Code: MBOT-303 (P)	Credits (L+T+P): 0+0+2

Laboratory Exercises:

1. Field trips to study the diversity of Gymnosperms.
2. Study of morphology and anatomy of vegetative and reproductive parts of different genera as mentioned in theory syllabus.
3. Prepare the permanent slides to study the anatomical details of different Gymnospermic woods.
4. Study of important fossil Gymnosperms with the help of permanent slides.

Course: Plant Biotechnology	
Course Code: MBOT-304	Credits (L+T+P): 3+1+0

Introduction to Plant Biotechnology

Define plant biotechnology, various techniques applied in plant biology, scope and application of plant biotechnology.

Plant Tissue Culture a) History and Importance of Plant Tissue Culture; Totipotency; Organogenesis; Embryogenesis (somatic and zygotic); Culture Media, Nutrients; Protoplast isolation, culture and fusion, Hybridisation of protoplasts. b) Tissue culture applications: Micropropagation, Androgenesis, Virus elimination.

Cryopreservation; Germplasm Conservation, Synthetic Seed preparations.

Introduction to Genetic Engineering

Basics of Gene Manipulation, Concepts and scope of genetic engineering, Milestones in Plant Recombinant DNA Technology. Importance of gene manipulation in future perspectives.

Tools in Genetic Engineering: Enzymes in genetic engineering - Restriction endonucleases (History, Types I-IV, biological role, types and action and application. Cloning vectors: Plasmids isolation and purification- Ti Plasmid, pBR322, pUC - series. Phage vectors-M13 phage vectors, Cosmids -Types, Phasmids or Phagemids, Shuttle vectors-types. YAC and BAC vectors, Lambda phage vectors, and Lamda phage DNA as a vectors. Cloning vectors and expression vectors.

Techniques for plant Transformation

Integration of plant tissue culture in to plant transformation protocols. Introduction, *Agrobacterium* mediated gene transfer, Ti-plasmid, process of T-DNA transfer and integration, Practical applications of *Agrobacterium*-mediated plant transformation, Transformation in Plants, Direct gene transfer methods.

Applications of Biotechnology

GM crops for insect/pathogen resistance/ herbicide tolerance/ Pest resistant (Bt-cotton); herbicide resistant plants (Round Up Ready soybean); Transgenic crops with improved quality traits (Golden rice); Improved horticultural varieties (Moondust carnations); Role of transgenics in bioremediation (Superbug).

Plant Molecular Biology

Organisation and function of Plant nuclear genome (*Arabidopsis thaliana*), Genetic transformation of plants by *Agrobacterium*: Genetic organization of Ti plasmids Functions encoded by integrated T-DNA. Molecular mechanism involved in transformation of plants by *Agrobacterium tumefaciens*.

Crop improvement in terms of yield and quality

Molecular markers (RFLP, RAPD and DNA finger printing) in crop improvement program. Transgenic plants resistant to insect. Biosafety and bioethics.

Suggested Readings:

- Brown, T.A. (1989). Genetics: A molecular Approach. VNR International.
- Brown, T.A. (2010). Genomes. John Wiley and Sons Pvt. Ltd., Singapore.
- Brown, T.A. (2010). Gene cloning and DNA Analysis- An introduction. 6th Edn. Wiley Blackwell.
- Bhojwani, S.S. and Razdan, M.K. (2005). Plant Tissue Culture: Theory and Practice. Revised Edn. Elsevier Science Publication, The Netherlands.
- Bhojwani, S.S. (2013). Plant Tissue Culture: Applications and Limitations. Elsevier Science Publishers, New York, USA.
- Chrispeels, M.J. and Sadava, D.E. (1994). Plants, Genes and Agriculture. Jones & Bartlett

Publishers, Boston, USA. 7. Das, H.K. (2007).

- A Textbook of Biotechnology. 3rd Edn. Wiley India Pvt. Ltd. U.P., India.
- Glezer, A.N. and Nikaido, H. (1995). Microbial Biotechnology. W.H. Freeman and Company, New York, USA.
- Glick, B.R., Pasternak J.J. and Patten, C.L. (2010). Molecular Biotechnology: Principles and Applications of Recombinant DNA. 4 th Edn. A.S.M. Press, Washington, DC.
- Henry, R.J. (1997). Practical Applications of Plant Molecular Biology. Chapman & Hall, London, UK.
- Jolles, O. and Jornvall, H. (2000). Proteomics in Functional Genomics. Birkhauser Verlag, Basel, Switzerland.
- Primrose, S.B. (1995). Principles of Genome analysis. Blackwell Science Ltd., Oxford, UK. 13.
- Raghavan, V. (1997). Molecular Biology of Flowering Plants. Cambridge University Press, New York, USA.
- Jain, S.M., Sopory, S.K. and Veilleux, R.E. (1996). In vitro Haploid Production in Higher Plants-Fundamental Aspects and Methods. Vols. 1-5. Kluwer Academic Publishers, Dordrecht, the Netherlands.
- Kartha, K.K. (1985). Cryopreservation of Plant Cells and Organs. CRC Press, Boca Raton, Florida, USA. 16. Vasil, I.K. and Thorpe, T.A. (1994). Plant Cell and Tissue Culture. Kluwer Academic Publishers. The Netherlands.

Course: Plant Biotechnology - Practical	
Course Code: MBOT-304 (P)	Credits (L+T+P): 0+0+2

Laboratory Exercises:

1. Preparation of MS medium, B5 media, Shoot initiation media; root induction media.
2. In vitro sterilization and inoculation methods using leaf, shoot tip and nodal explants of tobacco. *Datura*, *Brassica* etc.
3. Isolation of plasmid DNA & Transformation of *E. coli* bacteria.
4. Isolation of protoplasts from leaf tissue and culture in media.

Following techniques will be demonstrated by You tube or by ICT support.

5. Study of anther, embryo and endosperm culture, micropropagation, somatic embryogenesis &

artificial seeds.

6. Study of methods of gene transfer: Agrobacterium-mediated, direct gene transfer by electroporation, microinjection, microprojectile bombardment.
7. Study of genetic engineering steps for Bt cotton, Golden rice production. photographs.

Course: Plant Propagation Techniques	
Course Code: MBOT-305	Credits (L+T+P): 3+1+0

Plant propagation- History, scope and importance. Propagation structures with reference to greenhouse equipment and media. Seed propagation, Germination, type of seed dormancy and breaking, techniques of seed production and handling principles.

Modes of vegetative propagation. Vegetative propagation - advantages and limitations, natural and artificial means. Propagation by specialized vegetative structures- bulbs, tubers corms, rhizomes, runners and suckers. Propagation by cutting and layering- types of cuttings and layering, description of adventitious root and bud formations; processes in layering. Grafting and budding- concept and types, formation of graft union, graft incompatibility, top budding and micro-budding.

Advantage, limitations and applications of vegetative propagation, clones, genetic variation in asexually propagated plants, different methods.

Micropropagation - Techniques and applications in forestry and horticulture. Advantage, limitations and applications of vegetative propagation, clones, genetic variation in asexually propagated plants, different methods.

Seed production in plants. Biology of propagation in plants- General account of sexual and asexual means and their correlation with genetic variability; seedlings versus clonal propagation. Sexual seed - structure, development, ripening and dissemination. Apomixis - phenomenon and implications; concept of asexual seeds and polyembryony. Propagation from seeds - germination process, dormancy- its types and control, methods to break dormancy.

Propagation methods of some selected plants - Apple, Citrus, Grape, Mango, Mulberry, Hibiscus, Rose, Croton, Eucalyptus.

Suggested Readings:

1. Abbott, A.J. and Atkin, R.K. (eds.) 1987 Improving vegetatively propagated crops. Academic press, New York.
2. Bose, T.K., Sadhu, M.K., & Das, P., 1986. Propagation of Tropical and Subtropical Horticultural crops, Nowya Prakash, Calcutta.
3. Hartmann and Kester, 1983. Plant propagation.
4. Hartmann, H.T., Kester E.D., Davis, F.T., and Geneve, R.L. 1997. Plant propagation. Principles and practices. Prentice Hall of India Private Limited, New Delhi.
5. Krishnamurthy. H.M. 1981. Plant Growth substances including application in Agriculture.
6. L.M. Pierik 1987. *In vitro* culture of higher plants. Murtinus Nijhoff pub. Dordrecht.
7. M.K. Razdan 1994. An Introduction to Plant tissue culture, Oxford and IBH Pub. Co., PVT. Ltd., Bombay and Calcutta.
8. Mac Donald, B. 1987. Practical woody plant propagation for nursery growers. Portland, OR: Timber press.
9. Sadhu, M.K. 1989. Plant propagation Wiley eastern Ltd. N. Delhi.
10. Hartman, H.J. 1990. Plant Propagation: Principles and practices. Prentice Hall, New Delhi.
11. Sadhu, M.K. 2000. Plant Propagation. New Age Publication, New Delhi.
12. Schwalz, M. 1975. Guide to commercial hydroponics. Israel University, Jerusalem.
13. Sharma, V.K. 1996. Plant nurseries. Techniques, production and management. Indian Pub. New Delhi.
14. Razdan, M.K. (1993). An Introduction to Plant Tissue Culture. Oxford & BDH Publishing Co. Pvt. Ltd.
15. Sadhu, M.K. (1999). Plant Propagation. New Age International (P) Limited Publishers, New Delhi.

Course: Plant Propagation Techniques - Practical	
Course Code: MBOT-305 (P)	Credits (L+T+P): 0+0+2

Laboratory Exercises:

1. Principles and Techniques of Propagation by Cuttings.
2. Tissue Culture, Micropropagation.

3. Principles and Techniques of Propagation by Seed.
4. Vegetative propagation: types of cuttings.
5. Vegetative propagation: tapes of grafting.
6. Vegetative propagation: types of budding.
7. Vegetative propagation: types of layering.
8. Propagation by modified stems.
9. Propagation by modified roots.
10. Micro propagation: preparation of media, preparation of explants, culture, initiation of shoot.
11. Multiplication (demonstration).
12. Pot and green house implants (demonstration).

Course: Biology and Diversity of Angiosperms	
Course Code: MBOT-306	Credits (L+T+P): 3+1+0

Fossil Angiosperms

- i) General account of fossil Angiosperms
- ii) Origin and evolution of Angiosperms (Special reference to Bennettitalean, Gnetalean, Caytonialean and Pentoxylalean theories)

Taxonomy

1. Systems of Angiosperm Classification.

- i) Phenetic vs Phylogenetic system
- ii) Relative merits and demerits of major systems of classification
- iii) APG Classification

2. International Code of Botanical Nomenclature

- i) History
- ii) Principles and rules
- iii) Type method
- iv) Principle of priority and its limitations
- v) Names of Hybrids and cultivars

3. The Species Concept

Taxonomic hierarchy: species, genus, family and other categories

4. Modern taxonomy

Taxonomy in relation to anatomy, embryology, palynology, cytology, secondary metabolites in plants

5. Numerical Taxonomy

- i) Concept, characters and attributes
- ii) OTU's
- iii) Cluster analysis
- iv) Cladistics

Systematics in Practice

- i) Importance and role of herbarium, specimens and their preparation
- ii) Botanical Gardens, their importance and role
- iii) Value of computers and databases for plants identification

Concepts of Phytogeography

- i) Endemism, hotspots and hottest hotspots
- ii) Plant exploration, invasion and introductions
- iii) Local plant diversity and its socio-economic importance

Plant Resource Conservation

- i) Principles of conservation
- ii) Extinctions
- iii) Environmental status of plants based on IUCN
- iv) Strategies for *In-situ* and *Ex-situ* conservation
- v) IPR and biopiracy

Suggested Readings:

- Coble, A.J. (1969). Numerical Taxonomy. Academic Press, London.
- Davis, P.H and Heywood, V.H. (1973). Principles of Angiosperm Taxonomy. Robert E. Kreuger Pub. Co., New York.
- Eames, A.J. (1961). Morphology of the Angiosperms. McGraw- Hill, New York.
- Harrison, H.J. (1971). New Concepts in Flowering Plant Taxonomy. Hieman, London.
- Heywood, V.H. and Moore, D.M. (1984). Current Concepts in Plant Taxonomy. Academic Press, London.
- Heywood, V. (1995). Global Biodiversity Assessment. Cambridge Univ., Cambridge.

- Radford, A.E. (1986). Fundamentals of Plant Systematics. Harper and Row, USA.
- Stace, C.A. (1989). Plant Taxonomy and Biosystematics. Edward Arnold, London.
- Takhtajan, A.L. (1997). Diversity and Classification of Flowering Plants. Columbia University Press, New York.
- Woodland, D.W. (1991). Contemporary Plant Systematics. Prentice Hall, New Jersey.

Course: Biology and Diversity of Angiosperms - Practical	
Course Code: MBOT-306 (P)	Credits (L+T+P): 0+0+2

Laboratory Exercises:

1. To give taxonomic description of different flowering plants.
2. To study primitive and advanced character of various flowering plants.
3. Field trips to study diversity of Angiosperms.
4. To study diversity and distribution of invasive species.

Course: Tissue Culture and Horticultural Sciences	
Course Code: MBOT-307	Credits (L+T+P): 3+1+0

Tissue Culture

- i) Methods of tissue culture
- ii) Nutrient media used for *in vitro* culture of plant tissues
- iii) Cellular totipotency
- iv) Haploid induction; fundamental aspects
- v) Protoplasts; their isolation, culture and fusion
- vi) Applied aspects of tissue culture
 - a) Clonal propagation
 - b) Propagation of pathogen-free plants
 - c) Germplasm storage and conservation

Horticultural Sciences

1. Nomenclature for cultivated plants

2. Methods of propagation
3. Growth regulators and their use in horticulture
4. *In vitro*-pollination
5. Weed control
6. Principles of landscaping
7. Types of gardens

Suggested Readings:

- Davis, H. and Heywood, V.H. (1963). Principles of Angiosperm Taxonomy. Oliver and Boyd Edinburgh and London.
- Hartman, H. and Kester, D.E. (1972). Plant Propagation - Principles and Practices. Prentice Hall.
- Raghavan, V. (1976). Experimental Embryogenesis in Vascular Plants. Academic Press, London.
- Stanley, R.G. and Linskens, H.F. (1974). Pollen - Biology, Biochemistry, Management. Springer Berlin- Heidelberg New York.

Course: Tissue Culture and Horticultural Sciences - Practical	
Course Code: MBOT-307 (P)	Credits (L+T+P): 0+0+2

Laboratory Exercises:

1. To study media components and preparation
2. To study various sterilization techniques.
3. Micropropagation of plants by shoot tip and nodal culture methods.
4. Identification of various horticultural crops
5. To study nutrient deficiency in horticultural plants.

Course: Wood Science and Forest Biodiversity	
Course Code: MBOT-308	Credits (L+T+P): 3+1+0

1. Structure of vascular cambium and its role on wood formation.
2. Biochemical components of wood and their distribution in woody cell wall.
3. Basic Structure, formation and modifications of the woody cell wall.
4. Structure, identification and evolution of coniferous woods with particulars reference to Chir Pine, Blue Pine, Deodar, Fir, Spruce, Cypress and Yew.
5. Structure, identification and evolution of dicot woods with particulars reference to Sal, Teak, Shisham, Walnut, Mulberry, Indian Oak, Toon and Himalayan poplar.
6. A general account of texture, figure, spiral grain and knots in woods.
7. Forest Diversity: A general concepts of forest biodiversity, sustainable development and conservation of plant resources, endemism and importance of wild plants.
8. Plant Resources I - Vascular Cryptogams: Economic importance and distribution of vascular cryptogams in the Himalaya with particular reference to Himachal Pradesh.
9. Plant Resource II - Gymnosperms: Economic importance and distribution of Gymnosperms of India with particular reference to Himachal Pradesh.
10. Plant Resource III - Woody Plants (Shrubs, Lianas and Trees): Economic importance of woody plants and their distribution in Himachal Pradesh.
11. Forest Conservation: Factors contributing to the loss of forest biodiversity, IUCN categories of threat and Red Data Book, principles and practices for conservation.

Suggested Readings:

- Bawa, R. and Khosla, P.K. (1998). Biodiversity of Forest Species (A Community Forestry Approach). Bishen Singh Mahendra Pal, Dehradun. 218pp.
- Carlquist, S. (1988). Comparative Wood Anatomy-Systematic, Ecological and Evolutionary Aspects of Dicotyledonous Woods. Springer Verlag, Berlin.
- Dhar, U. (ed.) (1993). Himalayan Biodiversity. Him Vikas Publication No. 3, Gyanodya Prakashan, Nainital, 543pp.
- Heywood, V.H. and Watson, R.T. (1995). Global Biodiversity Assessment. UNEP, Cambridge University Press, Cambridge, U.K.
- Jane, F.W. (1970). The Structure of wood. Adam and Charles Blanck, London.

- Kothari, A. (1997). Understanding Biodiversity: Life Sustainability and Equity. Orient Longman.
- Krattiger, A.F. *et. al.* (eds.) (1994). Widening Perspectives on Biodiversity. Natraj Publishers, Dehradun. 473pp.
- Nair, M.N.B. (1998). Wood Anatomy and Major Uses of Woods. Faculty of Forestry, University Putra, Malaysia, 434 PM Serdong, Selangor, Malaysia.
- Nair, M.N.B. *et. al.* (eds.) (1998). Sustainable Management of Non-wood Forest Products. University Putra Malaysia, 434004 PM Serdong, Selangor, Malaysia.
- Panshin, A.J. and de Zeeuw, C. Textbook of Wood Technology. Vol. I. Tata McGraw Hill Book Co., New York.
- Rao, R.R. (1994). Biodiversity in India (Floristic Aspect). Bishen Singh Mahendra Pal Singh, Dehradun. 315pp.
- Seth, M.K. (2002). Tress and Their Economic importance.
- Seth, M.K., Kumari, A., Thakur, R. and Khullar, S.P. (2002). Pictorial Guide to Common Himalayan Pteridophytes Vol. I. Pteridophytes of Shimla.
- Seth, M.K., Chandel, S. and Thakur, R. (2002). Pictorial Guide to Some common Ornamental Plants in the Himalaya Vol. I.
- Seth, M.K., Sharma, S. and Chandel, S. (2002). Shrubs and Their Economic Importance. Prof. S.P. Khullar's Festschrift Volume.
- Timell, T.E. (1986). Compression of wood in Gymnosperms Vols. I-III. Springer - Verlag, Berlin, Heidelberg, New York, Tokyo.

Course: Wood Science and Forest Biodiversity - Practical	
Course Code: MBOT-308 (P)	Credits (L+T+P): 0+0+2

Laboratory Exercises:

1. To describe three dimensional structure of wood.
2. Examine the permanent slides to differentiate soft wood and hard wood.
3. To study T.S., L.S., T.L.S. and R.L.S. of different wood trees.
4. Field trips to study the diversity of forest plant resources.

Semester – IV

Course: Anatomy, Palynology and Reproductive Biology of Angiosperms

Course Code: MBOT-401

Credits (L+T+P): 3+1+0

Plant Anatomy

- i) Plant tissues: General account of different types of tissues (Root, Stem and Leaf)
- ii) Apical, lateral and intercalary meristems - their ultrastructure, histochemistry and organogenesis
- iii) Secondary growth in general and anomalous secondary growth in stem
- iv) Ecological anatomy

Palynology

- i) Basic techniques to study pollen
- ii) Pollen viability and storage
- iii) Pollen allergy

Reproductive Biology

1. Male Gametophytes:
 - i) Structure of anthers ii) Microsporogenesis ii) Role of tapetum iv) Pollen development v) Male sterility vi) Sperm dimorphism vii) Pollen tube growth and guidance
2. Female Gametophytes:
 - i) Ovule development ii) Megasporogenesis iii) Structure and organization of the embryo sac iv) Nutrition of the embryo sac.
3. Pollen-pistil interaction and fertilization:

Pollen-stigma interaction, sporophytic and gametophytic self-incompatibility (Cytological, biochemical and molecular aspects, *in vitro* fertilization)
4. Seed Development
 - i) Endosperm development during early, maturation and desiccation stages.
 - ii) Embryogenesis: ultrastructure and nuclear cytology.
 - iii) Embryo culture
5. Seed Dormancy
 - i) Importance and types of Dormancy
 - ii) Overcoming seed dormancy

Suggested Readings:

- Bhojwani, S.S and Bhatnagar, S.P. (2000). The Embryology of Angiosperms. Vikas Publishers.
- Bhojwani, S.S and Radan, M.K. (1983). Plant Tissue Culture: Theory and Practices. Elsevier, Amsterdam.
- Burgess, J. (1985). An Introduction to Plant Cell Development. Cambridge Univ. Press, Cambridge.
- Fahn, A. (1982). Plant Anatomy. Pergamon Press, Cambridge.
- Falk, D.A., Olwell, M. and Millan, C. (1996). Restoring Biodiversity. Columbia, USA.
- Howell, S.H. (1998). Molecular Genetics and Plant Development. Cambridge Univ., Cambridge.
- Lyndon, R.F. (1990). Plant Development: The Cellular Basis. Springer.
- Raghvan, V. (1999). Development Biology of Flowering Plants. Springer Verlag, New York.
- Shivanna, K.R. and Rangaswamy, N.S. (1992). Pollen Biology: A Laboratory Manual. Springer Verlag, Berlin.
- Shivanna, K.R. and Johri, B.M. (1985). The Angiosperms Pollen: Structure and Function. Wiley Eastern Ltd., New York.

Course: Anatomy, Palynology and Reproductive Biology of Angiosperms - Practical	
Course Code: MBOT-401 (P)	Credits (L+T+P): 0+0+2

Laboratory Exercises:

1. To study the V.S of Apical meristem.
2. To cut and stain T.S of different plants to study anomalous secondary growth.
3. To study the permanent slides of Hydrophytes and Xerophytes.
4. To study the permanent slides of ovules, anther and embryo sac.
5. To perform Pollen viability test.
6. To cut and stain T.S of Root, Stem and Leaves (Dicot and Monocot).

Course: Plant Resource Utilization and Breeding

Course Code: MBOT-402

Credits (L+T+P): 3+1+0

1. **Forest Products-Wood and Timber:** General Introduction, formation and composition of wood, difference between softwood and hardwood, Sapwood and Heartwood, storied and non-storied wood, ring-porous and diffuse-porous wood, annual rings, properties and seasoning of wood, uses of wood, structure and identification of important timber plants namely *Pinus*, *Cedrus*, *Tectona* and *Populus*.
2. **Nonwood Forest Products-I:** Bamboo-The Green Gold of India, its structure, properties and uses.
3. **Nonwood Forest Products-II:** Cork -Its structure, properties and uses.
4. **Nonwood Forest Products-III:** Tannins and Dyes -A general account.
5. **Nonwood Forest Products-IV:** Gums and Resins - A general account.
6. **Plant Resources-I:** Aromatic plants - a general account, essential oils and perfumery.
7. **Plant Resources-II:** Psychoactive drugs and poisons from plants -a general account.
8. **Plant Resources-III:** Fruits and nuts-a list of important fruits and nuts with particular reference to Himachal Pradesh (Details are not required).
9. **Plant Resources-IV:** Underexploited/underutilized plants-Winged or Goa Bean (*Psophocarpus tetragonolobus*), Jojoba or Hohoba (*Simmondsia chinensis*), Guayule or Wuyule (*Parthenium argentatum*), Subabul (*Leucaena leucocephala*) and Triticale (*Triticosecale*). A general account of edible wild plants.
10. **Plant Resources-V:** Medicinal plants -Some important medicinal plants with reference to Western Himalaya.
11. **Plant Resources-VI:** Bioenergy (Biofuels) of plant origin-A general account of fuel wood, energy plantations, organic waste materials for energy, petroleum plants, alcohol fuel and biogas.
12. A general account of the origin of cultivated plants with special reference to Vavilov's Centres of origin.
13. A general account of plant introduction and acclimatization.
14. Methods and modes of reproduction in relation to breeding in self-pollinated, cross pollinated, vegetatively propagated and apomictic plants.
15. A general account of inbreeding depression and heterosis, exploitation of hybrid vigour,

production of hybrids, composites and synthetics.

Suggested Readings:

- Anonymous, (1975). Underexploited Tropical Plants with Promising Value. National Academy of Sciences. Washington, D.C. 190 pp.
- Anonymous (1980). Firewood Crops: Shrubs and Tree Species for Energy Production. National Academy of Sciences, Washington, D.C. 237pp.
- Arora, R.K. and Pandey, A. (1996). Wild Edible Plants of India: Diversity, Conservation and Use. ICAR, NBPGR, New Delhi.294pp.
- Chaudhari, H.K. (1971,1986). Elementary Principles of Plant Breeding. Oxford and IBH Publishing Co., Pvt. Ltd., New Delhi.327pp.
- Chopra, V.L. (2001). Plant Breeding: Field Crops. Oxford and IBH Pvt. Ltd., New Delhi.
- Chopra, V.L. (2001). Plant Breeding: Theory and Practice. Oxford and IBH Pvt. Ltd., New Delhi.
- Kocchar, S.L. (1998). Economic Botany of the Tropics, 2nd Ed. MacMillan India Ltd., Delhi.
- Poehlmann, J.M. and Sleeper, D.R. (1995). Breeding Field Crops. Panima Publishing House, New Delhi.
- Sambamurthy, A.V.S.S. and Subramanyam, N.S. (1989). A Textbook of Economic Botany. Wiley Eastern Ltd., New Delhi.
- Sharma, J.R. (1994). Principles and Practices of Plant Breeding. Tata McGraw Hill Publishing Co., New Delhi. 599pp.
- Sharma, O.P. (1996). Hills economic Botany (By Late Dr. A.F. Hill and Adapted by Dr. O.P. Sharma). Tata McGraw Hill Co. Ltd., New Delhi. 731pp.
- Simpson, B.B. and Conner-Ogorzaly, M. (1986). Economic Botany- Plants in our World. McGraw Hill, New York. 640pp.

Course: Plant Resource Utilization and Breeding - Practical	
Course Code: MBOT-402 (P)	Credits (L+T+P): 0+0+2

Laboratory Exercises:

1. Describe the three dimensional structure of Wood.
2. Prepare and examine the permanent slides to differentiate Soft wood and Hard wood.

3. To study T.S, L.S, T.L.S. and R.L.S. of different types of wood.
4. To analyze different constituents of plant based products like Triphala, Chewing Pan, Cigarette, Bidi etc.
5. To study the morphology and anatomy of Cereals and Pulses.
6. To study different types of Fruits and Vegetables as mentioned in theory Syllabus.
7. To study different vegetative propagules.
8. Field visit to botanical gardens or seed banks.

Course: Advances in Mycology and Plant Pathology

Course Code: MBOT-403(i)

Credits (L+T+P): 3+1+0

1. Ecology of fresh water fungi, thermophiles and psychrophiles.
2. Domestication and Mycophagy: edible and poisonous mushrooms, mushroom toxins, cultivation technology for button and oyster mushrooms, diseases and pests of button mushrooms, nutritional and nutraceutical potential of mushrooms.
3. Growth, nutrition, differentiation and metabolites of fungi.
4. Mycotoxins and their medical and veterinary effects.
5. Effect of parasitic fungi on man.
6. Angiosperms, algae and protozoa as plant pathogens.
7. Plant injury due to insects, mites, nematodes and other pests.
8. Molecular basis of plant pathogenesis.
9. Mechanism of disease induction by fungi, bacteria, mycoplasma and viruses.
10. Eco-friendly approaches in plant disease management.
11. Mechanism of action fungicides.

Suggested Reading:

- Ainsworth, G.C. and Sussman, A.S. (1968). The fungi. Academic Press, New York.
- Alexopoulos, C.J. and Mims, C.W. and Blackwell, M. (1979). Introductory Mycology. Wiley Eastern Limited, New Delhi.
- Burnett, J.H. (1976). Fundamentals of Mycology. Edw. and Arnold, London.
- Alexopoulos, C.J., Mims, C.W. and Blackwell, M. Introductory Mycology. John Wiley and Sons.

- Deacon, J.W. Introduction to Modern Mycology. ELBS.
- Horsfall, J.G. and Cowling, E.B. Plant Disease Vol. I-V. Academic Press, New York.
- Moore-Landekar, E.J. (1972). Fundamentals of the fungi. Prentice hall, Englewood Cliffs.
- Burnett, H.L. Fundamentals of Mycology. Edward Arnold, London.
- Aneja, K.R. and Mehrotra, R.S. Introductory Mycology.
- Dube, H.C. An introduction to fungi. Vikas Publ., New Delhi.
- Agrios, G.N. (1988). Plant Pathology, Academic Press.
- Baker, F. and Cook, R.J. (1974). Biologist Control of Plant Pathogen. W. H. Freeman & Co. Ssan Francisco.
- Bilgrami, K.S. and Dubey, H.C. (1980). Text Book of modern, Plant pathology, Vikas, New Delhi.
- Horsfall, J.G. and Cowling, E.B. Plant pathology- An Advanced Treatise. Vol- III Academic Press, New York.
- Horsfall, J.G. and Cowling, E.B. Plant Disease Vol. I-V. Academic Press, New York.
- Mehrotra, R.S. Plant Pathology, Tata McGraw Hill Publishing Company, New Delhi.
- Tarr, S.A.J. (1972). Principals of Plant Pathology Mc Millan.
- Wood, R.K.S. (1967). Physiological Plant Pathology Blackwell Scientific Publications.

Course: Advances in Mycology and Plant Pathology - Practical

Course Code: MBOT-403(i) (P)

Credits (L+T+P): 0+0+2

Laboratory Exercises:

1. Learning the methods of sterilization, media preparation, test tube slant preparation and techniques of inoculation.
2. Morphological studies and identification of the local mushroom flora and of preserved specimen of mushrooms.
3. Sterilization of media and glass ware, preparation of culture of some local mushroom fungal species.
4. Preparation of different types of spawn.

5. Trips to mushroom research/cultivation centre to become familiarize with mushroom cultivation technology.

Course: Advances in Applied Microbiology	
Course Code: MBOT-403(ii)	Credits (L+T+P): 3+1+0

1. Food Microbiology:

- i) Types of microorganisms in food
- ii) Food spoilage
- iii) Methods of food preservation
- iv) Food poisoning
- v) Microbiology of milk and milk products.

2. Industrial Microbiology:

- i) Types of fermentation
- ii) Fundamentals of Bioreactor design
- iii) Microbial production of acetic acid, alcohol, cyanocobalamin, citric acid and penicillin
- iv) Yeast as fermentative agent in food and beverage production

3. Environmental and agricultural Microbiology:

- i) Microbiology of air, water and sewage
- ii) Microbial degradation of organic matter in soil
- iii) Nitrogen fixation by microorganisms
- iv) Microbial pesticides

4. Medical Microbiology:

- i) Brief account of causal agents, main symptoms, route of infection and control of following disease: Cholera, Diphtheria, Leprosy, Syphilis, Tetanus, Tuberculosis, Typhoid, Whooping Cough, Dysentery (Amoebic and bacterial), Kala Azzar, AIDS, Rabies, Japanese encephalitis
- ii) Mechanisms of microbial pathogenicity.
- iii) Host-parasite interactions

5. Immunology:

- i) Nature of antigen and antibody

- ii) Types of immunoglobulins
- iii) Types of immunity: Brief account of active, passive, innate and acquired immunity
- iv) Common antigen-antibody reactions: agglutination, precipitation, complement fixation, immunofluorescence, radioimmunoassay, enzyme linked immunosorbent assay (ELISA), neutralization.
- v) Brief account of hypersensitivity and autoimmunization.

Suggested Books:

- Jay, J.M. (1987). Modern food Microbiology. CBS Publishers and Distributors, New York.
- Casida, L.E. (1968). Industrial Microbiology. Wiley.
- Stolp, H. (1988). Microbial ecology: Organisms, Habitats and Activities. Cambridge University Press, Cambridge.
- Ananthanaryan, R. and Paniker, J.C.K. (1986). A Text Book of Microbiology (3rd limiteded.). Orient Longman Madras.
- Joshi, K.R. and Osamo, N.O. (1992). Immunology. Agro Botanical Publishers (India) Bikaner.
- Frazier, W.C. and Westhoff, D.C. (1995). Food Microbiology. Tata McGraw Hill Publishing Company Ltd., New Delhi.
- Prescott, L.M. Harley, J.P. and Klein, D.A. Microbiology. WCB Brown Publishers.
- Tortora, G.J., Funke, B.R. and Case, C.L. Microbiology- An Introduction. Addison Wesley Longman, Inc. California.

Course: Advances in Applied Microbiology - Practical	
Course Code: MBOT-403(ii) (P)	Credits (L+T+P): 0+0+2

Laboratory Exercises:

1. Learning the methods of sterilization of glassware and media preparation for the isolation of different pathogenic microorganisms.
2. Study the bacteria through Gram's staining methods.
3. Determination of quality of milk sample by methylene blue reductase test and resazurin method.
4. Isolation of yeast and molds from spoiled nuts, fruits and vegetables.
5. Isolation of microflora from air, water and sewage.

6. Isolation and enumeration of soil microorganisms (bacteria, fungi and actinomycetes).
7. Evaluation and isolation of nitrogen fixers *Rhizobium* from root nodule of legumes.
8. Study the ABO blood group system through agglutination reactions.

Course: Ethnobotany and Biodiversity Conservation	
Course Code: MBOT-404(i)	Credits (L+T+P): 3+1+0

1. Traditional botanical knowledge
2. History, scope and importance of Ethnobotany
3. Role of Ethnobotany in healthcare and development in cottage industry in India
4. Methods of research in Ethnobotany
5. Sources of information on plant resources of India
6. Global importance of medicinal plant
7. Conservation of plant genetics resources: The role of Biotechnology
8. Biodiversity: Concepts, extent and status of Biodiversity in India, causes of biodiversity loss, sustainable utilization of biological resources
9. Himalayan plant resources
10. Wasteland management in Himalayan region
11. Remote sensing and Bio-resources
12. Bio-indicators
13. Red Data Book

Suggested Readings:

- Cotton, C.M. (1996). Ethnobotany - Principles and applications. John Heywood, Wiley.
- Jain, S.K. (ed.). A Manual of Ethnobotany. Scientific Pub., Jodhpur.
- Jain, S.K. (ed.) (1989). Methods and Approaches in Ethnobotany. Surya Pub., Dehradun.
- Swaminathan, M.S. and Kocchar, S.L. (eds.) (1989). Plants and Society. Macmillan.
- Wagner, H., Hikino, H. and Farnsworth, N. (1989). Economic and Medicinal Plant Research Vols.1-3. Academic Press, London.

Course: Ethnobotany and Biodiversity Conservation	
Course Code: MBOT-404(i) (P)	Credits (L+T+P): 0+0+2

Laboratory Exercises:

1. Visits to tribal areas and collection of plant material used by tribes.
2. Identification and description of 10 plants of ethnobotanical value.
3. Identification and description of 10 plants used by tribals for their household.
4. Collection of plants used by tribals in their socio-cultural customs and taboos.
5. Collection of 5 plants used by the tribals in their magico-religious beliefs.
6. Field trip to study and collect different wild edible fruits.

Course: Ethnobotany, Bioprospecting and Traditional Knowledge	
Course Code: MBOT-404(ii)	Credits (L+T+P): 3+1+0

1. Ethnobotany: Introduction, relevance and scope; International, National and Regional contributions (J.W. Harshberger, R.E. Schultes, E.K. Janakiammal, S.K. Jain, P. Pushpangadan).
2. Centres of Ethnobotanical studies in India, AICRPE-All India Coordinated Research Project on Ethnobiology, FRLHT- Foundation for the Revitalisation of Local Health Traditions. Contribution of AICRPE and FRLHT to ethnobiology of India.
3. Tribal/Folk Communities of Himachal Pradesh with particular reference to anthropology, customs and beliefs.
4. NWFP (Non Wood Forest Produces) used by the tribal and folk communities of Himachal Pradesh. Plants used by ethnic groups as food, medicines, beverages, fodder, fibre, resins, oils and other uses.
5. Role of Ethnobotany in conservation and sustainable development.
6. Role of Ethnobotany in herbal-medicine industry, land-use development, agriculture, forestry, betterment of rural livelihood and education.
7. Biopiracy and Intellectual Property Rights (IPR).
8. Role of Ethnobotany in primary healthcare programmes and development of new drugs. Commercialization of traditional medicine.

9. Traditional/Indigenous knowledge and its importance.
10. Indigenous systems of medicines in India.

Suggested Readings:

- Cunningham, A.B. (2001). Applied Ethnobotany. Earthscan Publishers Ltd., London & Sterling, VA, USA.
- Cotton, C.M. (1996). Ethnobotany- Principles and application. John Wiley & Sons Ltd., West Sussex, England.
- Faulks, P.J. (1958). An Introduction to Ethnobotany. Moredale Publ., London.
- Jain, S.K. (1981). Glimpses of Indian Ethnobotany. Oxford & IBH publishing Co. Pvt. Ltd., New Delhi.
- Jain, S.K. (1989). Methods and approaches in Ethnobotany. Society of Ethnobotanists, Lucknow.

Course: Ethnobotany, Bioprospecting and Traditional Knowledge - Practical	
Course Code: MBOT-404(ii) (P)	Credits (L+T+P): 0+0+2

Laboratory Exercises:

1. Field trip to local/tribal communities to survey, document and explore information on plant-people relationship.
2. Collection, processing and preservation of ethnobotanical specimens.
3. Exploration and Documentation of Traditional Knowledge among local communities.
4. To calculate Importance Value Index (IVI) of some traditionally important plants.
5. To find out the nutraceutical potential of some important wild edible plants used by local communities.

Course: Advances in Plant Physiology and Biochemistry - I	
Course Code: MBOT-405(i)	Credits (L+T+P): 3+1+0

1. Some important phytochemical techniques: Principles and applications of chromatography, spectrophotometry, electrophoresis, centrifugation and tracer techniques.

2. Physiology and biochemistry of phytohormones: Structure, biosynthesis, metabolism, transport, function and mechanism of action of auxins, gibberellins, cytokinins, ethylene, abscisic acid, brassinosteroids, polyamines, jasmonic acid and salicylic acid.
3. Synthetic growth regulators: Discovery, chemical nature, effects on growth on growth and development and mechanism of action of growth inhibitors and retardants.
4. Signal transduction: Overview, receptors and G proteins, phospholipid signaling, role of cyclic nucleotides, calcium-calmodulin cascade, diversity in protein kinases and phosphatase, sucrose-sensing mechanism.
5. Seed Physiology: Seed viability, longevity, biochemical deterioration, seed dormancy, metabolism of germinating seeds, environmental and hormonal control of seed dormancy/germination.
6. Senescence: Physiological and biochemical basis of senescence.
7. Stress Physiology: Concept of biological stress, plant responses and mechanism of tolerance of various abiotic stresses: Water deficit stress, salinity stress, heavy metal toxicity and stress, freezing and heat stress, oxidative stress.

Suggested Readings:

- Annual reviews of plant physiology and plant molecular biology.
- Aspinall, D. and Paleg, L.G. (eds.) (1981). The Physiology and Biochemistry of Drought Resistance in Plants. Academic Press. London.
- Bewley, J.D. and Black, M. (1982). Physiology and Biochemistry of seeds Vol. 1 and 2. Springer Verlag.
- Buchanan, B.B., Gruissem, W. and Jones, R.L. (2000). Biochemistry and Molecular Biology of Plants. American Society of Plant Physiologists, Maryland, USA.
- Freifelder, D. Physical Biochemistry.
- Goodwin, T.W. and Mercer L.E. (1989). Introductory Plant Biochemistry. Pergamon Press, New York, USA.
- Moore, T.C. (1989). Biochemistry and Physiology of Plant Hormones (2nd edition). Springer Verlag, New York, USA.
- Salisbury, F.B and Ross, C.W. (1992). Plant Physiology (4th edition). Wadsworth Publishing Company California, USA.

- Taiz, L. and Zeiger, E. (1998). Plant Physiology (2nd edition), Sinauer Associates Inc. Publishers, Massachusetts, USA.
- Wilkins M.B.(ed.) (1984). Advanced Plant physiology ELBS, Longman, U.K.

Course: Advances in Plant Physiology and Biochemistry - I (Practical)	
Course Code: MBOT-405(i) (P)	Credits (L+T+P): 0+0+2

Laboratory Exercises:

1. To study the effect auxin on rhizogenesis in *Vigna munga*.
2. To study the effect of kinetin and ABA in leaf senescence.
3. To separate the amino acid by paper chromatographic technique.
4. To determine the Km value for α -amylase from germinating wheat seeds.
5. To determine the absorption spectrum of anthocyanin in a given tissue.
6. To estimate the protein content in the germinating seeds of *Phaseolus vulgaris* by Lowey's method.
7. To separate the chloroplastic pigments from the given leaves by chemical method.
8. To estimate the free proline content in normal and water stressed leaves of *Tropaeolum majus*.
9. To determine the Stomatal index of the given leaves.
10. To assay α -amylase activity from germinating seeds.
11. To determine and compare the activity of catalase in the given tissue.
12. Determination of water potential by plasmolytic methods.

Course: Advances in Plant Physiology and Biochemistry - II	
Course Code: MBOT-405(ii)	Credits (L+T+P): 3+1+0

1. Sensory Photobiology: Structure, function and mechanisms of action of phytochromes, cryptochromes and phototropins; Photophysiology of light induced responses; Stomatal movement; photoperiodism and biological clocks and its regulation.
2. Physiology of plant development and flowering: Embryogenesis - apical-basal and radial patterning; Developmental control of root and shoot apical meristem; leaf development and;

Concept of Florigen, transition to flowering, floral meristems and floral development in *Arabidopsis*.

3. Membrane transport: An overview of transport; pumps, carriers and channels; mechanism of transport of micromolecules.
4. Fruit development and ripening: Stages of fruit development and their regulation, physiology and biochemistry of fruit abscission, production of transgenic fruits. Post harvest technology; Physiological changes during ripening, fruit preservation, role of ethylene in post-harvest technology.
5. Chemical defence: Biochemical mechanisms of plant's chemical war against other plants and animals. Plant responses to herbivory; constitutive defence mechanisms; induced phytochemical responses; biochemical mechanisms of allelopathy.
6. Plant tissue culture: History, basic concept, principle, scope and techniques. Cellular differentiation, totipotency and callus formation.

Suggested Readings:

- Bhojwani, S. S. (2012). *Plant Tissue Culture: Applications and Limitations*. Elsevier Science. <https://books.google.co.in/books?id=ySl6kafETMIC>
- Heldt, H. W., & Piechulla, B. (2010). *Plant Biochemistry*. Elsevier Science. <https://books.google.co.in/books?id=3DQQggoHy6YC>
- Lyndon, R. (2013). *Plant Development: The Cellular Basis*. Springer Netherlands. <https://books.google.co.in/books?id=4BhJCAAAQBAJ>
- Macias, F. A., Galindo, J. C. G., & Molinillo, J. M. G. (2003). *Allelopathy: Chemistry and Mode of Action of Allelochemicals*. CRC Press. <https://books.google.co.in/books?id=B0937BBWXjQC>
- Nath, P., Bouzayen, M., Mattoo, A. K., & Pech, J. (2014). *Fruit Ripening: Physiology, Signalling and Genomics*. CABI. <https://books.google.co.in/books?id=hceWBAAAQBAJ>
- Nelson, D. L., & Cox, M. (2017). *Lehninger Principles of Biochemistry: International Edition*. Macmillan Learning. <https://books.google.co.in/books?id=mv5TvgAACAAJ>
- Taiz, L., Møller, I. M., Murphy, A., & Zieger, E. (2022). *Plant Physiology and Development*. Oxford University Press, Incorporated. <https://books.google.co.in/books?id=EG63zgEACAAJ>
- Trigiano, R. N., & Gray, D. J. (2016). *Plant Tissue Culture, Development, and Biotechnology*. CRC Press. <https://books.google.co.in/books?id=I0LOBQAAQBAJ>

- Yahia, E. M., & Carrillo-Lopez, A. (2018). *Postharvest Physiology and Biochemistry of Fruits and Vegetables*. Elsevier Science. <https://books.google.co.in/books?id=IMlaDwAAQBAJ>

Course: Advances in Plant Physiology and Biochemistry - II (Practical)	
Course Code: MBOT-405(ii) (P)	Credits (L+T+P): 0+0+2

Laboratory Exercises:

1. Measurements of photosynthesis rates using Pulse amplitude modulated (PAM) fluorometers under different light conditions.
2. To study the effect of photoperiodism on germination and seedling growth of long day and short day plants.
3. To demonstrate the phototropism using the black-box method.
4. To study and compare the anatomy of Root and Shoot apical meristem.
5. Effect of plant extracted allelochemicals on seed germination and seedling growth.
6. Role of different phytohormones on callus induction and plantlet regeneration.
7. To estimate the sugar content in raw and ripened fruit.
8. A field trip to study the techniques of fruit development, ripening, Transgenic fruits, and Post-Harvest Technology.

Course: Phytochemistry and Palynology of Plant Kingdom - I	
Course Code: MBOT-406(i)	Credits (L+T+P): 3+1+0

Introduction to phytochemistry, brief history of modern phytochemistry, relation of phytochemistry with other sciences.

Classification of phytochemicals, sources of phytochemicals, biological effect of phytochemicals and function of phytochemicals in living organisms. Role of phytochemicals in plant disease management. Skills and expertise required for a phytochemist. Computer-aided phytochemical studies.

Secondary metabolites (alkaloid, flavonoids, phenolic compounds, steroids, terpenoids, lectin and non-protein amino acids), their classification, properties, distribution, structure and their applications in human welfare.

Pesticidal properties of compounds of plant origin.

Brief account on: Acetate mevalonate pathway, acetate malonate pathway and Shikimic acid pathway for synthesis of phytochemicals.

Phytochemistry of Turmeric: General chemical class and identification tests, specific tests for markers, special reference to phenols (curcuminoids).

Phytochemistry of Ginger: General chemical class and identification tests, specific tests for markers, special reference to phenols (gingerols).

Phytochemical constituents of fungi and lichens and their medicinal importance.

Define nutraceuticals, classification of nutraceuticals, source of nutraceuticals, nutraceuticals and diseases and scope of nutraceuticals. Plant based nutraceuticals and their advantages.

Bio-chemicals from algae, pigments, essential fatty acids, polysaccharides, wax, hydrocarbons and plant growth regulators.

Biochemicals present in phytoplankton and other aquatic plants and their benefits to human welfare.

Define allelopathy and its role in agriculture, allelochemicals, their source, distribution, mode of action and their effect on growth of various crops. Biosynthesis pathway of allelopathic inhibitor. Allelopathy with specific reference to plants of north-western Himalaya. Application of allelopathy in weed management.

Suggested Readings:

- Buchanan, B.B. Greuisssem, W. and Jones, R.L.2000. Biochemistry and Molecular Biology of plants.
- Robinson, T. 1968. The Biochemistry of Alkaloids Springer Verlag, Berlin.
- Mukherjee, Pulok, Quality control of herbal drugs, business, horizon limited, New Delhi.
- J B Harborne, Chapman and Hall, Phytochemical methods, International Ed., London.
- Mann J Davidson, R S & J B Hobbs, D V Banthrope, J B Harborne 1994. Natural products. Longman Scientific and Technical Essex.
- Pharmacognosy by C.K. Kokate , Publisher: Nirali Prakashan.
- Pharmacognosy by Trease & Evans.
- Pharmacognosy & Phytochemistry by Vinod Rangari.
- Chemistry of Natural Products: A Laboratory Handbook by Krishnaswamy NR.
- Bruneton J., 1999. Pharmacognosy, Phytochemistry, Medicinal Plants, Intercept Ltd., Paris.

- Dewick P.M., 2002. Medicinal Natural Products: A biosynthetic approach, John Wiley & Sons Ltd.
- Evans W.C., 2002, Trease and Evan's Pharmacognosy,
- W.B. Saunders. 4. Harborne, J.B., 1998. Phytochemical Methods, Chapman and Hall.
- Houghton P.J. and A. Raman, 1998. Laboratory handbook for fractionation of natural extracts, Chapman and Hall.
- Kokate C.K., 1991. Practical Pharmacognosy, Vallabh Prakashan, Delhi.
- Annidation and Allelopathy by Arun Katyan.
- Allelopathy basic and applied aspects. S. J. H. Rizvi, V. Rizvi.
- Allelopathy. Elroy Rice.
- Allelopathy in Crop Production. Shamsheer S. Narwal.
- Handbook of Nutraceuticals and Functional Foods. Robert E.C. Wildman, Richard S. Bruno.
- Nutraceuticals and Functional foods in Human Health and Disease Prevention. Debasis Bagchi, Dr. Anand Swaroop, Harry G. Press.

Course: Phytochemistry and Palynology of Plant Kingdom – I (Practical)

Course Code: MBOT-406(i) (P)

Credits (L+T+P): 0+0+2

Laboratory Exercises:

1. Demonstration of Soxhlet extraction methods.
2. Tests for detection of Phenol, Steroids, alkaloids, and terpenoid.
3. Allelopathic effect of parthenium hysterophorus on seed germination of any crop plants.
4. Isolation, purification, and identification of alkaloids by application of column chromatography
5. Phytochemical screening and detection of carbohydrates (Mollish test, Benedict test and Fehling test).
6. Extraction of alkaloids and flavonoids from plant material by using TLC.
7. Qualitative phytochemical screening of: (a) Phenolics (B) Saponin (C) Tannin.
8. Solvent extraction and Chemical tests for the detection of alkaloids, phenols, anthraquinones, cardenolides, anthocyanins, betacyanins, carotenoids.
9. Anatomical studies (under microscope) from some commercially available powder drugs.

10. TLC for isolation of compounds: Anthocyanin from cabbage and betacyanin from beet root.
11. Phytochemical analysis of some lichens of your locality.
12. Phytochemical analysis of some algae and phytoplankton of water bodies of your locality.
13. To analyse the nutritive content of some wild edible plants of your locality.
14. To analyse the nutraceutical potential of some wild edible fruits.

Course: Phytochemistry and Palynology of Plant Kingdom - II	
Course Code: MBOT-406(ii)	Credits (L+T+P): 3+1+0

General aspects of Palynology, Historical background, Historical background, definition, basic concept, scope, interrelationships with other branches of botany. Application of India work on Palynology, Palynology centre in India.

Pollen morphology: Spore and pollen morphology, size, shape, Symmetry of Pollen, Saccate and non Saccate, pollen apertural types, NPC of apertures, Pollen wall structure, Sporoderm stratification. Frageri, Iverson and Erdtman's view regarding the structure of pollen wall. Sculptures of pollen wall, Evolutionary trends in exine. Methods of preparation of pollen grains for morphological studies.

Pollen morphology of following angiosperms family: (1) Asteraceae (2) Brassicaceae (3) Combretaceae (4) Malvaceae (5) Rutaceae.

Palynotaxonomy: Taxonomic significance of Palynology - Eurypolyny and Stenopolyny in angiosperms.

Identification key and evolutionary trends among pollen grains based on palynotaxonomical work.

Palynological description and Pollen types of following: (1) *Hibiscus* (2) *Citrus* (3) *Ocimum* (4) *Tribulis* (5) *Tridax*.

Aeropalynology and its application: Methods of Aerospora survey and analysis, pollen allergy and pollen calendar system for pollen allergy. Mechanism of Hypersensitivity type -1 caused by pollens.

Melissopalynology: Pollen and nectar collection by honeybee; Importance of pollen grains as constituent of bee-bread, pollen-collecting mechanism of honey bees, analysis of pollen load and objectives of melissopalynological studies, important honey plant resources of North- West Himalaya.

Pollen germination and Pollen tube growth: Methods of pollen germination and pollen tube growth. Factors involved in the pollen germination *in vitro* and *in vivo*.

Pollen viability, pollen preservation, controlling factors, Cryopreservation, Pollen banks and their role in agriculture and plant breeding. Pollen culture, pollen embryoid and pollen culture

Application of palynology: Palynology in oil-exploration, forensic science, honey analysis and in detection and diagnosis of pollen and spore allergy.

Suggested Readings:

- Erdtman, G. 1952. Pollen morphology and Plant taxonomy, Angiosperms, Almquist and Wiksell, Stockholm.
- Maheshwari P. 1950. An introduction to the embryology of Angiosperms.
- Heslop-Harrison J. 1971. Pollen development and Physiology.
- Shivanna KR. 2003. Pollen biology and biotechnology.
- T.S. Nayar. 1990 Pollen flora of Maharashtra state, India.
- G. Thanikaimoni. 1970 Mangrove Palynology.
- P.K.K. Nair. 1970 Pollen morphology of angiosperms.
- Shripad N. Agashe, 2006. Palynology and its applications.
- Kashinath Bhattacharya, 2006. A textbook of Palynology.
- Crane, Eva; Walker, Penelope and Day Rosemany, 1984. Directory of Important World Honey Sources: International Bee Research Association, London.
- Hutchinson, J. 1973. The Families of flowering Plants 2 Vols. Oxford University Press. Oxford.
- Takhtajan, A.L. 1997. Diversity and classification of flowering plants. Columbia University Press. N. York.
- Bhojwani, S.S. and Bhatnagar, S.P. 2000. The embryology of Angiosperms. Vikas Publ. House, NewDelhi.
- Aghwan, V. 1997. Molecular embryology of flowering plants. Cambridge Univ. Press, Camp.
- Shivanna, K.R. and Sawhney, V.K. 1997. Pollen biotechnology for crop production and improvement Cambridge Univ. Press.

Course: Phytochemistry and Palynology of Plant Kingdom – II (Practical)	
Course Code: MBOT-406(ii) (P)	Credits (L+T+P): 0+0+2

Laboratory Exercises:

1. Study of *in vivo* and *in vitro* germination of pollen grains.
2. Study of allergy producing pollen morpho-types.
3. Study of pollen morphology using Chitale and Acetolysis method from families Asteraceae, Brassicaceae, Convolvulaceae, Lamiaceae and Poaceae.
4. Study of Acetolysed pollen preparation of various angiosperms and Gymnosperm taxa.
5. *In vitro* prick test for conformation of pollen allergy.
6. Woodhouse technique and preparation of permanent slides of plant taxa.
7. Study of the growth of pollen tube through stigma and style.
8. Study of *in vivo* and *in vitro* germination of pollen grains.
9. Study of Pollen calendar of North -western Himalyan region (H.P.)
10. Extraction of pollen grains from honey sample and study of the frequency of different morpho-types.
11. Pollen *in vitro* germination method: sitting drop culture, Suspension culture, Surface culture.
12. Corelation between fertility, viability (TTC and FDS staining) and germinability (*in vitro*) of pollen grain.