# University of Kalyani


## M.Sc. Botany
## Choice Based Credit System

## Syllabus

(2017 – onwards)

Department of Botany
Kalyani - 741235

## REGULATIONS RELATING TO THE CONDUCT OF UNIVERSITY EXAMINATIONS IN

## M.Sc. BOTANY - SEMESTER SYSTEM (CHOICE BASED CREDIT SYSTEM)

**DEFINITIONS**

1. ***'Programme'*** means the entire course of study and examinations (traditionally referred to as course).
2. ***'Duration of Programme'*** means the period of time required for the conduct of the program. The duration of post-graduate programme shall be 4 semesters.
3. ***'Semester'*** means a term consisting of a minimum of 90 working days including examination days distributed over a minimum of 18 weeks each of 5 working days.
4. ***'Course'*** means a segment of subject matter to be covered in a semester (traditionally referred to as paper).
5. ***'Credit'*** **(Cr*)*** of a course is a measure of the weekly unit of work assigned for that course.
6. ***'Letter Grade'*** or simply ***'Grade'*** in a course is a letter symbol (O, E, A, B, C, D, F) which indicates the broad level of performance of a student in a course.
7. Each letter grade is assigned a ***'Grade point'*** (G) which is an integer indicating the numerical equivalent of the broad level of performance of a student in a course.
8. ***'Credit point'*** (P) of a course is the value obtained by multiplying the grade point (G) by the Credit (Cr) of the course P=G x Cr.
9. ***Semester Grade point average'*** (SGPA) is the value obtained by dividing the sum of credit points (P) obtained by a student in the various courses taken in a semester by the total number of credits taken by him/her in that semester . The grade points shall be rounded off to two decimal places. SGPA determines the overall performance of a student at the end of a semester.
10. ***'Cumulative Grade point average'*** (CGPA) is the value obtained by dividing the sum of credit points in all the courses taken by the student for the entire program by the total number of credits and shall be rounded off to two decimal places.

**PROGRAMME STRUCTURE**

1. Students shall be admitted into post graduate Choice Based Course System in Botany under the Faculty of Science.
2. The programme shall include four types of courses, Hard core, Soft core, Elective and Open Courses. Hard core and Elective Courses have both theoretical and practical courses. Hard core courses are compulsory courses. Soft core and Elective courses should be opted by the students and allotted to them as per availability of the faculty. Open course should be offered to the students of other departments and M.Sc. Botany students should opt one open course from the P.G. subjects other than Botany. There shall be a Project /Dissertation in the Elective Course, to be undertaken by all students.
3. The Course of study shall extend over a period of two academic years and will be offered in four semesters: I and III semester: July to December; II and IV semester: January to June

4. The admission to the PG programme shall be as per the rules and regulations of the University.
5. The eligibility criteria for admission shall be as announced by the University from time to time.
6. The admission to the course shall only be in the first semester at the beginning of each academic year.
7. M.Sc. degree will be awarded to students who complete a total of 64 credits in a minimum of two years.

**ATTENDANCE**

8. A student is required to attend all classes. General and Practical class attendance will be counted separately.
9. For candidates taking late admission in the 1st Semester, attendance will be counted from the date of their admission.
10. A candidate shall be allowed to appear at any of the Semester examinations if he/she has attended 75% or above of the course lectures/practical classes held during that semester. If the attendance falls short of 75% but not below 60%, he/she will be allowed to appear at the examination as non-collegiate candidate on payment of requisite fees. Candidates attending less than 60% classes in any semester will be treated as discollegiate and will be debarred from appearing at the examination of that semester. He/she will be allowed to take re-admission in subsequent one semester only in the next year.
11. Shortage of attendance up to a maximum of 10% will be condoned, if (i) A student was away representing the University/State /Country in Athletic /Sports and Games/Cultural/N.C.C or any other important socio-intellectual event; (ii) Parents' appeal on health or on other serious grounds duly recommended by the Head concerned (An authentic certificate from appropriate authorities must be produced).

**EXAMINATION, EVALUATION AND GRADING**

12. The evaluation scheme for each course shall contain two parts: (a) Term-end evaluation and (b) Internal Assessment. 20% weightage shall be given to internal assessment and the remaining 80% to Term-end evaluation. Therefore the ratio and weightage between term-end and internal assessment is 4:1. The Course pattern will be as follows:

| Courses | Points in theoretical courses | | | Points in practical courses | | |
|---|---|---|---|---|---|---|
| | Term-end evaluation | Internal Assessment | Total | Term-end evaluation | Internal Assessment | Total |
| Hard core | 60 | 15 | 75 | 20 | 5 | 25 |
| Soft core | 40 | 10 | 50 | - | - | - |
| Open course | 80 | 20 | 100 | - | - | - |
| Elective course | 80 | 20 | 100 | 80 | 20 | 100 |
| Project/review | | | | | | 50 |

13. Duration of examination of theoretical courses up to 50 points shall be two hours, up to 60 points two and half hours, up to 75 points three hours and up to 100 points four hours. The

same for the practical courses up to 25 points shall be two hours and up to 75 points six hours generally.

14. To ensure transparency of the evaluation process, the internal assessment grade awarded to the students in each course in a semester shall be published on the notice board at least one week before the commencement of Term end examination.

15. In order to qualify in a semester examination, a student shall have to get minimum aggregate 40 points (**D and above on grade point scale**) in each course.

16. There shall generally be no retest for internal assessment. If a student misses a class test during an on going semester for health or other valid reasons, he/she may be given a second chance with the permission of the Departmental Committee. The student has to justify his/her absence by providing an authentic certified document. However, such a second chance shall not be the right of the student; it will be the discretion of the D.C. to give or not to give second chance to a student to appear for internal assessment.

17. For **Internal Assessment**, one class test for 25 points (for hard core courses) or 15 points (for soft core courses) or 35 points (for Elective and open courses) will be conducted comprising of objective and short type questions for each Course. The Class test will be for a duration of 60 minutes (for 25 points), or 45 minutes (for 15 points), or 90 minutes (for 35 points). Five points will be awarded for class attendance and/or assignments for each course during each semester. The total out of 30 or 20 or 40 points will finally be converted to 15 or 10 or 20 points. For scoring of attendance the following principle will be followed: ≥80%, 5; 79-70%, 4; 69-60%, 3; 59-50%, 2.

18. Internal marks will not change. A student cannot repeat Internal Assessment. Internal Assessment answer books shall be shown to the students concerned but not the end-semester answer scripts.

19. Students who have failed semester -end exam may reappear for the semester-end exam only twice in subsequent period. The student will be finally declared as failed if he\she does not pass in all credits within a total period of four years.

20. **(a)** A candidate who fails to qualify or fails to appear at not more than two theoretical / practical courses in a semester will be treated as Failed but Supplementary (FS) and will be allowed to prosecute studies in the next semester. He/she will generally be allowed to appear at supplementary examination for those papers in which he/she has failed. The date of supplementary examination will be announced later. However, his/her marks of qualified papers will be retained. **(b)** If a candidate fails to qualify or fails to appear at more than two theoretical /practical courses in a semester, he/she will be treated as Failed but Repeat (FR) and will have to repeat that semester as a whole in the next year. He/she will not be allowed to join classes of the next semester.

21. The candidate eligible for supplementary examination as per **20(a)** or eligible for repeat semester as per **20(b)** will get a chance to appear at maximum of two consecutive supplementary / total examinations in any semester. However a candidate will have to qualify in all the semesters within a span of four years from the year of admission.

22. A candidate who has failed in a theoretical course but has passed the practical course, based on the former, need not appear in the practical course in the supplementary examination.

23. According to the University Regulations, candidates can review only their theoretical answer scripts of Semester-End examination through the Office of the Controller of Examinations, Kalyani University. No application for reviewing of a practical paper shall be entertained. Similarly the internal assessment answer scripts will also not be reviewed.

24. The written answer scripts of each term end semester examination will be preserved according to the University Rules. Class test answer scripts will however be preserved in the Department for two years from the date of start of the concerned Semester. After that period, the scripts will be disposed of.

25. The semester end and final grade sheets and transcripts will have only grades and grade points average.

**GRADING SYSTEM**

| QUALIFICATION | GRADE | SCORE ON 100% POINTS | POINTS |
|---|---|---|---|
| Outstanding | O | 90-100 | 10 |
| Excellent | E | 80-89 | 9 |
| Very Good | A | 70-79 | 8 |
| Good | B | 60-69 | 7 |
| Fair | C | 50-59 | 6 |
| Below average | D | 40-49 | 5 |
| Fail | F | >40 | |

$SGPA^a$ = $\frac{\text{Sun of [Credits X Grade Point]}}{\text{Sum of credits of all papers in the semester}}$ calculated for each semester

$CGPA^b$ = $\frac{\text{Sem1GP X1 + Sem2GP X1 + Sem3GP X1.5 + Sem4GP X 1.5}}{5}$ for the entire course

[a] Semester Grade Point Average (SGPA)

[b] Cumulative Grade point Average (CGPA)

To satisfactorily complete the M.Sc. Course & qualify for the degree, a student must obtain a minimum CGPA of 5.

| CGPA | Division |
|---|---|
| **8-10** | **1st Div with Distinction** |
| **6.5-7.9** | **1st Div** |
| **5.5-6.4** | **2nd Div** |
| **6** | **2nd Div with 55%*** |
| **5-5.4** | **3rd Div** |

(* To convert CGPA into %: CGPA – 0.5 X 100)

26. The following academic calendar will be followed for each semester:

a. Duration of classes: Four and half months

b. Preparatory leave - Fifteen days maximum

c. Examination including Practical - Twenty days

# Outline of the Choice Based Course & Credit Semester System

**Course Categories:** **HC:** Hard Core; **SC:** Soft Core; **E:** Elective; **OC:** open course
**Course Transaction Categories:** **T:** Theory; **P:** Practical**; PW:** Project Work
**Evaluation Categories:** **IA:** Internal Assessment; **TEE:** Term End Examination

| Course | Course Name | Points | Credit | Hrs/wk |
|---|---|---|---|---|
| **SEMESTER I** | | | | |
| **HARD CORE THEORY** | | | | |
| BOHCT1.1 | Biology & Diversity of Virus, Bacteria & Fungi | 75 | 3 | 4 |
| BOHCT1.2 | Biology & Diversity of Algae, Bryophytes & Pteridophytes | 75 | 3 | 4 |
| BOHCT1.3 | Biology & Diversity of Gymnosperms, Taxonomy of Angiosperms & Biosystematics | 75 | 3 | 4 |
| BOHCT1.4 | Cytology, Cytogenetics & Genetics | 75 | 3 | 4 |
| **HARD CORE PRACTICAL** | | | | |
| BOHCP1.1 | Practical based on BOHCT1.1 | 25 | 1 | 3 |
| BOHCP1.2 | Practical based on BOHCT1.2 | 25 | 1 | 3 |
| BOHCP1.3 | Practical based on BOHCT1.3 | 25 | 1 | 3 |
| BOHCP1.4 | Practical based on BOHCT1.4 | 25 | 1 | 3 |
| **LIBRARY/ FIELD WORK/ CLASS TEST/ TUTORIAL** | | | | 2 |
| **Total Points & Credits in Semester I** | | **400** | **16** | **30** |
| | | | | |
| **SEMESTER II** | | | | |
| **HARD CORE THEORY** | | | | |
| BOOCT2.1 | Plants in human welfare | 100 | 4 | 4 |
| BOHCT2.2 | Plant Physiology and Biochemistry | 75 | 3 | 4 |
| BOHCT2.3 | Plant Embryology, Plant Breeding & Biometry | 75 | 3 | 4 |
| BOHCT2.4 | Palaeobotany, Palynology, Plant Anatomy | 75 | 3 | 4 |
| **HARD CORE PRACTICAL** | | | | |
| BOHCP2.2 | Practical based on BOHCT2.2 | 25 | 1 | 3 |
| BOHCP2.3 | Practical based on BOHCT2.3 | 25 | 1 | 3 |
| BOHCP2.4 | Practical based on BOHCT2.4 | 25 | 1 | 3 |
| **LIBRARY/ FIELD WORK/ CLASS TEST/ TUTORIAL/ SEMINAR PRESENTATION** | | | | 5 |
| **Total Points & Credits in Semester II** | | **400** | **16** | **30** |
| | | | | |
| **SEMESTER III** | | | | |

| Course | Course Name | Points | Credit | Hrs/wk |
|---|---|---|---|---|
| **HARD CORE THEORY** | | | | |
| BOHCT3.1 | Principles of Plant Pathology & Crop Protection | 75 | 3 | 4 |
| BOHCT3.2 | Plant Molecular Biology & Biotechnology | 75 | 3 | 4 |
| BOHCT3.3 | Principles of Plant Ecology & Biodiversity, Conservation | 75 | 3 | 4 |
| **SOFT CORE THEORY:** Any **two** from following | | | | |
| BOSCT3.1 | Environmental Biology | 50 | 2 | 2 |
| BOSCT3.2 | Forensic Botany | 50 | 2 | 2 |
| BOSCT3.3 | Industrial Microbiology | 50 | 2 | 2 |
| BOSCT3.4 | Medical Mycology | 50 | 2 | 2 |
| BOSCT3.5 | Economic Botany and Pharmacognosy | 50 | 2 | 2 |
| BOSCT3.6 | Stress Physiology | 50 | 2 | 2 |
| **HARD CORE PRACTICAL** | | | | |
| BOHCP3.1 | Practical based on BOHCT3.1 | 25 | 1 | 3 |
| BOHCP3.2 | Practical based on BOHCT3.2 | 25 | 1 | 3 |
| BOHCP3.3 | Practical based on BOHCT3.3 | 25 | 1 | 3 |
| **Elective Course (Theory/ Practical/ Project Work)** | | | | 3 |
| **LIBRARY/ FIELD WORK/ CLASS TEST/ TUTORIAL/ SEMINAR PRESENTATION** | | | | 2 |
| **Total Hard Core Points/ Credits in Semester - III** | | **300** | **12** | **18** |
| **Total Soft Core Points/ Credits in Semester – III** | | **100** | **4** | **4** |
| **Total Points/ Credits in Semester – III** | | **400** | **16** | **30** |
| **ELECTIVE THEORY: Elective Course allotment and classes will start in 3rd Semester** | | | | |
| **SEMESTER IV** | | | | |
| **ELECTIVE THEORY**<br>Any **one** single combination of Course – I & Course – II from the following- | | | | |
| BOET4.1 | Genetics, Molecular Genetics, Biometry & Plant Breeding Course-I | 100 | 4 | 6 |
| BOET4.2 | Genetics, Molecular Genetics, Biometry & Plant Breeding Course-II | 100 | 4 | 6 |
| BOET4.3 | Microbiology Course - I | 100 | 4 | 6 |
| BOET4.4 | Microbiology Course - II | 100 | 4 | 6 |
| BOET4.5 | Mycology & Plant Pathology Course - I | 100 | 4 | 6 |
| BOET4.6 | Mycology & Plant Pathology Course - II | 100 | 4 | 6 |
| BOET4.7 | Phycology Course - I | 100 | 4 | 6 |
| BOET4.8 | Phycology Course - II | 100 | 4 | 6 |
| BOET4.9 | Plant Physiology, Biochemistry & Plant Molecular Biology Course - I | 100 | 4 | 6 |

| Course | Course Name | Points | Credit | Hrs/wk |
|---|---|---|---|---|
| BOET4.10 | Plant Physiology, Biochemistry & Plant Molecular Biology Course - II | 100 | 4 | 6 |
| BOET4.11 | Pteridology & Palaeobotany Course - I | 100 | 4 | 6 |
| BOET4.12 | Pteridology & Palaeobotany Course - II | 100 | 4 | 6 |
| BOET4.13 | Taxonomy of Angiosperms & Biosystematics Course - I | 100 | 4 | 6 |
| BOET4.14 | Taxonomy of Angiosperms & Biosystematics Course - II | 100 | 4 | 6 |
| **ELECTIVE PRACTICAL** | | | | |
| BOEP4.1 | Practical based on BOET4.1 & 4.2 | 100 | 4 | 8 |
| BOEP4.2 | Practical based on BOET4.3 & 4.4 | 100 | 4 | 8 |
| BOEP4.3 | Practical based on BOET4.5 & 4.6 | 100 | 4 | 8 |
| BOEP4.4 | Practical based on BOET4.7 & 4.8 | 100 | 4 | 8 |
| BOEP4.5 | Practical based on BOET4.9 & 4.10 | 100 | 4 | 8 |
| BOEP4.6 | Practical based on BOET4.11 & 4.12 | 100 | 4 | 8 |
| BOEP4.7 | Practical based on BOET4.13 & 4.14 | 100 | 4 | 8 |
| **ELECTIVE COURSE PROJECT WORK** | | | | |
| BOEPW4.1 | Project Work | 50 | 2 | 6 |
| **SOFT CORE THEORY:** Any **one** from following | | | | |
| BOSCT4.1 | Evolution | 50 | 2 | 2 |
| BOSCT4.2 | Immunology | 50 | 2 | 2 |
| BOSCT4.3 | Intellectual Property Rights | 50 | 2 | 2 |
| BOSCT4.4 | Mycorrhiza and Lichens | 50 | 2 | 2 |
| BOSCT4.5 | Advanced Pteridology | 50 | 2 | 2 |
| **LIBRARY/ FIELD WORK/ CLASS TEST/ TUTORIAL/ SEMINAR PRESENTATION** | | | | 2 |
| **Total Elective Course Points/ Credits in Semester - IV** | | **350** | **14** | **28** |
| **Total Soft Core Points/ Credits in Semester – IV** | | **50** | **2** | **2** |
| **Total Points & Credits in Semester IV** | | **400** | **16** | **30** |
| **TOTAL POINTS & CREDITS** | | **1600** | **64** | **120** |

# Detailed Syllabus of the Choice Based Credit Semester System

## SEMESTER I

| Course | Subject | Points | Credits | Hrs./Wk. |
|---|---|---|---|---|
| **BOHCT1.1 (Group A + B + C)** | **Biology & Diversity of Virus, Bacteria & Fungi** | **75** | **3** | **4** |
| **BOHCP1.1** | **Practical based on BOHCT1.1** | **25** | **1** | **3** |
| **TOTAL** | | **100** | **4** | **7** |

**EVALUATION SCHEME - THEORY:** Internal Assessment (15) + Term End Examination (60)
TEE: Group A (20 points) + Group B (20 points) + Group C (20 points)
**PRACTICAL:** Internal Assessment (5) + Term End Examination (20)

### Theoretical course
### BOHCT1.1

### Group A
### Biology & Diversity of Virus

**TEE points: 20** **Classes/ Semester: 20**

1. Nature and origin of virion. (2)
2. Nomenclature and classification, distinctive properties of viruses, morphology (symmetry) and a general account on different types of viruses, Viral genome. (3)
3. Structure & chemistry of viruses-capsid and their arrangements, types of envelopes and their composition, Molecular organization of virion with special reference to TMV and HIV. (4)
4. Isolation, purification and identification of viruses based on chemical, physical and immunological techniques. (3)
5. Transmission of plant viruses, genetic basis of cell to cell movement of plant viruses. (2)
6. Management of plant viruses following classical and modern technique. (2)
7. Molecular basis of Lytic and Lysogenic cycle. (2)
8. Prions, viroids, virusoids, Satellite virus. (2)

### Group B
### Biology & Diversity of Bacteria

**TEE points: 20** **Classes/ Semester: 20**

1. Microbial taxonomy and phylogeny, major groups of Bacteria. (2)
2. Ultra structure of Gram positive and Gram negative bacteria. (2)
3. Bacterial motility, bacterial sporulation. (1)
4. Bacterial growth kinetics, factors affecting growth. (1)
5. Photolithotrophs, chemolithotrophs, photoorganotrophs & chemoorganotrophs, Mixotroph. (1)
6. Organization and replication of genetic material in bacteria. Genetic recombination (conjugation, transformation and transduction) in bacteria. (3)
7. Concept of microbial ecology with reference to air, water and soil. (2)
8. Microbes associated with food, food-borne infections and intoxications; preservation of food. (1)

9. Cells and organ of immune system, antigen (chemical nature and types), immunoglobulins (structure and types), brief idea about hypersensitivity and vaccine. (3)
10. Air, water, and soil-borne disease – causal organism, symptoms, control. (2)
11. Industrial production of ethanol, penicillin and vitamin B12. (1)
12. Cosmetic microbiology-current trends. (1)

**Group C**

**Biology & Diversity of Fungi and their allies**

**TEE points: 20** **Classes/ Semester: 20**

1. Distinctive features of fungi to form a separate kingdom; modern trends in classification (1)
2. The architecture of fungal cell, cell wall, cell membrane, cell organelles and cytoskeleton, nucleus and its division; biogenesis and protoplast technology; translocation in mycelia (2)
3. Genome organization in fungi; extra chromosomal and transposable genetic elements in fungi (2)
4. Somatic recombination in fungi: heterothallism; heterokaryosis and parasexuality (3)
5. Diversity of somatic, reproductive and fruiting structures in different groups: Myxomycota, Oomycota, Chytridiomycota, Zygomycota, Ascomycota, Basidiomycota, Deuteromycota (10)
6. Fungal spores: types, dispersal, dormancy and germination (2)

**Practical Course**

**BOHCP1.1**

**(Based on BOHCT1.1 – Biology & Diversity of Virus, Bacteria & Fungi)**

**Points: 25** **3 hours/ week**

1. Study of inclusion bodies in virus-infected plants, its distribution and orientation.
2. Study of epidermal pattern of virus-infected leaves with reference to change in stomatal index.
3. Biochemical study of detection of plant viruses.
4. Submission of field record along with herbarium sheets of virus-infected plants.
5. Isolation and enumeration of bacteria from soils and water samples.
6. Enrichment and isolation of free-living nitrogen fixing bacteria from soil.
7. Isolation and straining of *Rhizobium* from root nodule.
8. Determination of antibiotic sensitivity of some bacteria by disc diffusion method.
9. Determination of thermal death point of bacteria.
10. Construction of bacterial growth curve; Influence of inhibitor on bacterial growth.
11. Study of morphological and reproductive structures of some macro- and micro-fungi
12. Identification of different fruiting structures of macro-fungi, permanent slides with different reproductive structures of micro-fungi, spore forms of rust fungi, lichens

**Note: Regularly checked Laboratory records, permanent slides prepared during practical classes, preserved and dried specimens collected during field works should be submitted at the time of TEE.**

***** ***** *****

| Course | Subject | Points | Credits | Hrs./Wk. |
|---|---|---|---|---|
| **BOHCT1.2 (Group A + B + C)** | **Biology & Diversity of Algae, Bryophytes & Pteridophytes** | **75** | **3** | **4** |

| | | | | |
|---|---|---|---|---|
| **BOHCP1.2** | **Practical based on BOHCT1.2** | **25** | **1** | **3** |
| **TOTAL** | | **100** | **4** | **7** |

**EVALUATION SCHEME - THEORY:** Internal Assessment (15) + Term End Examination (60)
TEE: Group A (20 points) + Group B (20 points) + Group C (20 points)
**PRACTICAL:** Internal Assessment (5) + Term End Examination (20)

**Theoretical course**
**BOHCT1.2**

**Group A**
**Biology & Diversity of Algae**

**TEE points: 20** **Classes/ Semester: 20**

1. Modern trends: Outline of principles and recent trends in algal systematics; endosymbiotic theory of chloroplast evolution and algal origin. (2)
2. General overview & Resource utilization: Prochlorophyta; Glaucophyta; Dinophyta; Heterokontophyta: Bacillariophyceae, Xanthophyceae, Eustigmatophyceae; Bio-fertilizers and bio-molecules with commercial application. (7)
3. Cyanobacteria: Diversity of forms and habitats; cyanobacterial taxonomy; cyanobacterial evolution. (3)
4. Rhodophyta: Diversity of forms and habitats; evolutionary trends in red algae; ecology of red algae. (3)
5. Chlorophyta: Diversity of forms and habitats; evolutionary trends of green algal lineages; salient features of different classes of chlorophytes. (3)
6. Phytoplankton: Types of phytoplankton; algal blooms; algal toxins (2)

**Group B**
**Biology & Diversity of Bryophytes**

**TEE points: 20** **Classes/ Semester: 20**

1. General classification: Criteria, recent trends and outline of classification of the liverworts, mosses and hornworts. (8)
2. Phylogeny: Evolutionary significance and interrelationships; recent concepts on evolution of the three lineages (liverworts, mosses and hornworts). (4)
3. Biogeography and Ecological significance: Diversity and distribution patterns; population and community dynamics; physiological ecology and adaptations; ecological roles of bryophytes. (4)
4. Economic significance and Conservation: Economic importance; threats and vulnerability; conservation strategies; restoration ecology. (4)

**Group C**
**Biology & Diversity of Pteridophytes**

**TEE points: 20** **Classes/ Semester: 20**

1. Introduction: A general account and an outline of recent system of classification of Pteridophytes upto order level with characteristic features. (2)
2. Diversity and Evolution: Diversity in organography and the evolutionary trends in the members of Psilophyta, Lycophyta, Sphenophyta and Filicophyta - Early ferns, Eusporangiate ferns (Ophioglossales, Marattiales), Leptosporangiate ferns (Filicales, Marsileales, Salviniales). (5)
3. Gametophyte: Patterns of spore germination; patterns of gametophyte development in homosporous and heterosporous pteridophytes; mating system in fern. (3)
4. Sporophyte: Variations in vegetative and reproductive structures and their evolution with special emphasis on shoot apex, stelar organization, and soral characters. (4)

5. Cytogenetics and Speciations: Pteridophytes with low and high chromosome number; polyploidy in microphyllous and megaphyllus forms; intergeneric and interspecific hybridity; obligate interbreeding forms. (2)
6. Antheirdiogen in ferns. (2)
7. Habitat diversity of pteridophytes and their conservation; endemic and endangered pteridophytes with special reference to India. (2)

**Practical Course**
**BOHCP1.2**
**(Based on BOHCT1.2 – Biology & Diversity of Algae, Bryophytes & Pteridophytes)**

**Points: 25** **3 hours/ week**

1. Morphological study and identification of members of the major algal groups – Cyanobacteria, Rhodophyta and Chlorophyta.
2. Seaweed identification – *Enteromorpha, Ulva, Catenella, Padina* and *Sargassum.*
3. Phytoplankton identification – desmids, diatoms, dinoflagellates.
4. Collection of algae from different localities and through local tours; their preservation and identification.
5. Field record, collection and preservation of common algal taxa.
6. Morphological study and identification of members of the three lineages – Marchantiophyta, Bryophyta and Anthocerotophyta.
7. Identification of diagnostic features of preserved bryophytic specimens and permanent slides.
8. Collection of bryophytes from different localities and through local tours; their preservation and identification.
9. Field record, collection and preservation of common bryophyte taxa.
10. Comparative morpho-anatomical studies of vegetative and reproductive organs of some members of available pteridophytes with identification up to generic level.
11. Study of diagnostic features of important pteridophytic taxa .
12. Field record, collection and preservation of common pteridophytic taxa.

**Note: Regularly checked laboratory records, permanent slides prepared during practical classes, specimens collected during compulsory field works (preferably one long field visit) should be submitted in a standard manner along with Field Note Books at the time of TEE.**

***** ***** *****

| Course | Subject | Points | Credits | Hrs./Wk. |
|---|---|---|---|---|
| **BOHCT1.3 (Group A + B)** | **Biology & Diversity of Gymnosperms, Taxonomy of Angiosperms & Biosystematics** | **75** | **3** | **4** |
| **BOHCP1.3** | **Practical based on BOHCT1.1** | **25** | **1** | **3** |
| **TOTAL** | | **100** | **4** | **7** |

**EVALUATION SCHEME - THEORY:** Internal Assessment (15) + Term End Examination (60)
TEE: Group A (20 points) + Group B (40 points)
**PRACTICAL:** Internal Assessment (5) + Term End Examination (20)

**Theoretical course**
**BOHCT1.3**

**Group A**

**Biology & Diversity of Gymnosperms**

**TEE points: 20** **Classes/ Semester: 20**

1. Introduction: A general account and an outline of recent system of classification of gymnosperms upto order level with characteristic features. (2)
2. Palaeozoic Pteridosperms (Seed Ferns): Major events in evolution of Palaeozoic Pteridosperms; brief account of Lyginopteridaceae, Calamopityaceae, Medullosaceae, Callistophytaceae. (5)
3. Cycads & Cycadeoids: General traits, circumscriptions of the families of Cycads, early evidence, Cycad and Cyadeoid foliage. (2)
4. More diversification among gymnosperms: Brief account of Caytoniaceae, Corystospermaceae, Peltaspermaceae, Glossopteridceae, Pentoxylaceae. (5)
5. Ginkgos: General traits, early evidence, distribution in time and space. (1)
6. Conifers: General traits of conifers; first evidence of conifer organization - Cordaitales, Voltziales; origin of conifer cones and leaves; circumscriptions of the families of extant conifers and their interrelationships; comparative account among conifers on basis of the male gametophyte, pollination mechanisms, female gametophytes, proembryo development. (4)
7. Gnetophytes: General traits; characteristics features of the genera of Gnetopsida; comparisons amongst *Ephedra*, *Gnetum* and *Welwitschia.* (1)

**Group B**

**Taxonomy of Angiosperms & Biosystematics**

**TEE points: 40** **Classes/ Semester: 40**

1. Systems of angiosperms classification: Outline of classification of Cronquist (1988) and Takhtajan (1997) up to Subclasses / Super orders. Broad outline of angiosperm phylogeny Group (APG) III, 2009 with the outline concept of Palaeoherbs and Eudicots. (4)
2. A general survey of the following taxa of angiosperms (*sensu* Cronquiust, 1988) with reference to their characteristics, inter-relationship, evolutionary trends, changed concepts and economic importance in the light of recent researches: Amborellaceae, Magnoliales, Caryophyllidae, Nepenthales, Podostemales, Asterales, Alismatales and Poaceae. (10)
3. ICBN : Changes, addition and alteration of latest four codes; principles, rank of taxa and names of taxa, nomenclatural types, priority of publication and limitation of the priority of publications, effective and valid publications, author's citation; changes and rejection of names, preliminary concept of appendices. Principle idea about Bio-codes and Phylocodes. (4)
4. Concepts of phytogeography: Endemism in India; invasion and introduction of plants in India. (2)
5. Botanic Gardens and Herbaria: Importance, examples from India and abroad. (2)
6. Biosystematics: Definition, methods, categories, differences with classical taxonomy. (2)
7. Numerical Taxonomy: Definition, principles, logical steps, applications, merits and demerits. (3)
8. Evolutionary concept ; Basic idea about following terms - Plagiomorphy and Apomorphy; Parallelism and Convergence; Homology and Analogy; Monophyly and Polyphyly including the concept of Heterobathmy, Cline, Polarity, Anagenesis and Cladogenesis, Symplesiomorphy, Synapomorphy, Autopomorphy, Stasigenesis, Catagenesis, Paraphyly, Holophyly, Homoplasy; Phylogram, Dendrogram and Cladogram. (3)
9. Cladistics system of classifications of Angiosperms: Principles, methods, merits and demerits. (2)

10. Data sources of taxonomy: Embryology, photochemistry with brief account of DNA - Taxonomy, DNA - barcoding, e - Taxonomy; nuclear rDNA, chloroplast and mitochondrial DNA; ultrastructure of sieve tube plastids. (5)
11. Taxonomic literatures: Definitions with examples of classical books, index, flora and manual, revision and monograph, icons, bibliography, catalogue, encyclopedias, glossary and dictionary. Important periodicals of India and abroad. (3)

**Practical Course**

**BOHCP1.3**

**(Based on BOHCT1.3 – Biology & Diversity of Gymnosperms, Taxonomy of Angiosperms & Biosystematics)**

**Points: 25** **3 hours/ week**

1. Studies of morpho-anatomy of conifer leaves and their identification (at least five taxa).
2. Studies of reproductive structures of at least two conifers.
3. Characterization of at least four taxa of gymnosperms for identification.
4. Studies of morpho-anatomy of *Gnetum* and *Ephedra*.
5. Field record and plant collection to be submitted (not more than 10 herbarium specimens).
6. Drawing and description of specimens from representative locally available families.
7. Identification of family with the help of Keys of angiosperms by Davis and Cullen's book and Hutchinson's book.
8. Identification of genera and species with the help of local and regional floras.
9. Preparation of an artificial indented /bracketed key at family/generic/ species level, from locally available plants as well as, from the worked out plants.
10. Two compulsory local field excursions for familiarization with the local flora.
11. Herbarium specimens (at least 25) of wild plants abundant in the locality to be submitted at the term-end examination.

**Note: Regularly checked laboratory records and specimens collected during compulsory field works should be submitted in a standard manner along with Field Note Books at the time of TEE.**

***** ***** *****

| Course | Subject | Points | Credits | Hrs./Wk. |
|---|---|---|---|---|
| **BOHCT1.4** | **Cytology, Cytogenetics & Genetics** | **75** | **3** | **4** |
| **BOHCP1.4** | **Practical based on BOHCT1.4** | **25** | **1** | **3** |
| **TOTAL** | | **100** | **4** | **7** |

**EVALUATION SCHEME - THEORY:** Internal Assessment (15) + Term End Examination (60)
TEE: 60 points
**PRACTICAL:** Internal Assessment (5) + Term End Examination (20)

**Theoretical course**

**BOHCT1.4**

**Cytology, Cytogenetics & Genetics**

**TEE points: 60** **Classes/ Semester: 60**

1. Genome organization in Eukaryotes: DNA packing in nucleosome; repetitive, satellite and unique DNA sequences; C-value paradox; structural and functional organization of telomeres and centromeres; spindle organization, polymerization and significance. (5)
2. Karyotype concept in relation to evolution; banding techniques; GISH and FISH techniques. (4)
3. Sex determination: Sex determination in plants and their interrelationship with human, *Drosophila* and mice models; dosage compensation; sex linked inheritance. (4)
4. Special type chromosomes: Cytogenetical significance of polytene and B-chromosome; deletion mapping; recombination. (3)
5. Linkage and crossing over: chiasma frequency and genetic map distance; Evolutionary significance of recombination; tetrad analysis; centromere mapping with ordered tetrad. (5)
6. Reciprocal translocation: Cytogenetics of reciprocal translocation in plant species; Gaudens and Velans complex; reciprocal translocation in humans. (3)
7. Polyploidy: Polyploids and aneuploids; Inheritance of autopolyploids and trisomics; significance and limitations of polyploidy; aneuploidy in humans. (4)
8. Plastids and mitochondrial DNA influenced traits. (2)
9. Microbial genetics: Transformation, conjugation and transduction and their significance in gene mapping. (2)
10. Gene mutation: Induction, types, molecular basis, significance; paramutation; DNA repair mechanism; epigenetic changes; genetic imprinting; prion particles; site directed mutagenesis; gene complementation test; rII locus. (5)
11. Biology of DNA and RNA: DNA forms; DNA replication; transcription and translation processes; RNA types; characterization of rRNA; pre mRNA processing. (5)
12. Genetic regulation: Regulation of prokaryotic gene expression – *lac*, *trp* and *ara* operons; regulation of eukaryotic gene expression – brief account. (4)
13. Transposonal elements: Ac-Ds, IS elements, P-elements and their role in genetics. (2)
14. Population genetics: Hardy-Weinberg principle; gene frequency in a population, genetic equilibrium, factors affecting gene frequency. (3)
15. Cell cycle regulation and cancer: Role of proteins in controlling cell cycle; apoptosis; oncogenes and protooncogenes; tumour suppressor genes; role of E2F and $p^{53}$ in controlling cell cycle; cancer therapy. (6)
16. Recombinant DNA technology – brief account (3)

**Practical Course**

**BOHCP1.4**

**(Based on BOHCT1.4 – Cytology, Cytogenetics & Genetics)**

**Points: 25** **3 hours/ week**

1. Concept of karyotype analysis; karyotype analysis and ideogram preparation.
2. Determination of chiasma frequency.
3. Pollen mitosis – *Allium cepa*.
4. Determination of nucleolar frequency in a plant specimen?
5. Determination of mitotic index in a plant species.
6. Study of sex chromatin in cell population.
7. Determination of gene/allelic frequency from ABO blood group in human population.
8. Pollen fertility and viability analysis.
9. Localization of DNA *in situ*.
10. Testing goodness of fit from the supplied samples.

11.Reciprocal translocation and inversion heterozygosity (demonstration).
12.Macromutation and polyploidy (demonstration).
13.Protein and DNA separation by gel electrophoresis (demonstration).

**Note: Regularly checked laboratory records, permanent slides prepared during practical classes should be submitted in a proper way at the time of TEE.**

***** ***** *****

## SEMESTER II

| Course | Subject | Points | Credits | Hrs./Wk. |
|---|---|---|---|---|
| **BOOCT2.1** | **Plants in human welfare** | **100** | **4** | **4** |
| **EVALUATION SCHEME - THEORY Internal Assessment (20) + Term End Examination (80)** | | | | |
| | **TEE: 80 points** | | | |

### Theoretical course
### BOOCT2.1

### Plants in human welfare

**TEE points: 80** **Classes/ Semester: 80**

1. Know your plants (12)
2. Exploitation of microbes (8)
3. Mushrooms – their uses and cultivation (8)
4. Environmental clean-up by plants (8)
5. Stress in plants (8)
6. Genetically modified crops (8)
7. Exploitation of plant resources (8)
8. Conservation of plants (8)
9. Plants in forensic science (8)
10. Intellectual Property Rights (4)

***** ***** *****

| Course | Subject | Points | Credits | Hrs./Wk. |
|---|---|---|---|---|
| **BOHCT2.2** | **Plant Physiology and Biochemistry** | **75** | **3** | **4** |
| **BOHCP2.2** | **Practical based on BOHCT2.3** | **25** | **1** | **3** |
| **TOTAL** | | **100** | **4** | **7** |
| **EVALUATION SCHEME - THEORY:** | **Internal Assessment (15) + Term End Examination (60)** | | | |
| | **TEE: 60 points** | | | |
| **PRACTICAL:** | **Internal Assessment (5) + Term End Examination (20)** | | | |

### Theoretical course
### BOHCT2.2

### Plant Physiology & Biochemistry

**TEE points: 60** **Classes/ Semester: 60**

1. Water and Plant Cells: Water in Plant life, structure and properties of water, water potential chemical properties of water, water potential of Plant Cells, major factors contributing cell water potential, cell wall and membrane properties. (3)
2. Water balance of Plants: Water in the Soil, Water absorption by roots, Water transport through Xylem, Water movement from leaf to atmosphere, Soil-Plant-atmosphere continuum. (3)
3. Cell wall structure, biogenesis; membrane transport processes; solute transport and photo assimilate translocation (4)
4. Signal transduction: Signal transduction in eukaryotes. (3)
5. Sensory photobiology: Light control of plant development; phytochrome: properties, phytochrome induced response, phytochrome signaling pathways, blue light responses. (3)
6. Plant hormones and growth regulators: Chemistry, biosynthesis, physiological effects, and signal transduction pathways of auxins, gibberellins, cytokinin, ethylene, abscisic acid, brassinosteroids, polyamines, jasmonates. (6)
7. Growth and developmental physiology: Embryogenesis and differentiation of plant organs Seed germination and seedling growth. (4)
8. Senescence and programmed cell death: Types of senescence, metabolic changes associated with senescence and its regulation, influence of hormones. (2)
9. Control of flowering: Floral meristem and floral organ development, floral evocation. (3)
10. Stress physiology: Response and adaptation to abiotic stress: water stress, temperature stress (heat and cold stress). Gene regulation and proteomics of stress tolerance, Development of transgenic plants to stress tolerance. (4)
11. Principle of biophysical chemistry: pH, buffer, reaction kinetics, thermodynamics, law of mass action, acid base reactions, bond energy, energy rich compounds, redox potential, free energy. (4)
12. Enzyme: Enzyme kinetics, catalytic reactions and regulatory properties, inhibitions, iso-enzymes, allosterism, ribozyme and abzymes, vitamins as coenzymes. (4)
13. Chemistry of plant products: structure and properties of carbohydrates, lipids, amino acids, proteins, nucleic acids, secondary metabolites. (6)
14. Photosynthesis: Light reactions, organization of light absorbing system, mechanism of electron and proton transport, Carbon concentrating mechanisms. (4)
15. Energy yielding metabolisms: Paths of energy synthesis through Glycolysis, Citric acid cycle, plant mitochondrial electron transport chain, alternative oxidase, PPP cycle, regulation of respiratory pathways, Lipid metabolism: fatty acid biosynthesis and oxidation. (4)
16. Nitrogen metabolism: Biological and non biological nitrogen fixation, nitrate and ammonium assimilation. (3)

**Practical Course**

**BOHCP2.2**

**(Based on BOHCT2.2 – Plant Physiology & Biochemistry)**

**Points: 25** **3 hours/ week**

1. Estimation of sulphur.
2. Estimation of reducing sugar.
3. Effect of substrate concentration on enzyme activity and determination of $K_m$.
4. Effect of temperature and pH on enzyme activity.

5. Study of invertase, diastase and urease activity.
6. Measurement of water potential of plant tissue.
7. Extraction of fat by Soxhlet's apparatus.
8. Determination of acid value and saponification value of fat.
9. Induction of α-amylase synthesis in aleurone cells of rice grains by $GA_3$.
10. Paper chromatography of amino acids.
11. Effect of uncoupler on rate of respiration.
12. Study of Hill reaction in isolated chloroplast.
13. Effect of anti-transpirant on the rate of transpiration.

***** ***** *****

| Course | Subject | Points | Credits | Hrs./Wk. |
|---|---|---|---|---|
| **BOHCT2.3 (Group A + B)** | **Plant Embryology, Plant Breeding & Biometry** | **75** | **3** | **4** |
| **BOHCP2.3** | **Practical based on BOHCT2.4** | **25** | **1** | **3** |
| **TOTAL** | | **100** | **4** | **7** |
| **EVALUATION SCHEME - THEORY:** | **Internal Assessment (15) + Term End Examination (60)** | | | |
| | **TEE: Group A (20 points) + Group B (40 points)** | | | |
| | **PRACTICAL: Internal Assessment (5) + Term End Examination (20)** | | | |

**Theoretical course**
**BOHCT2.3**

**Group A**
**Plant Embryology**

**TEE points: 20** **Classes/ Semester: 20**

1. Plant development: Concept, definition and unique features of development in plants. (2)
2. Transition from vegetative to reproductive phase: morpho-histochemical changes in shoot apex floral meristem and floral organ development in *Arabidopsis*. (4)
3. Molecular genetics in Plant Development: Techniques of studying plant developmental pattern: Mutants and transgenics in plant development. (3)
4. Gametogenesis fertilization and early development:
   i. Development of stamen, anther, sporogenous tissue, microspores, pollen and male germ unit. Molecular basis of male gametophyte development. (2)
   ii. Development of carpel, ovule, megaspore, female gametophyte and female germ unit. Molecular basis of female gametophyte development. (2)
   iii. Genetic and molecular basis of self incompatibility. Fertilization, double fertilization, triple fusion, imprinting and endosperm development in gymnosperms and angiosperms, embryogenesis in gymnosperms and angiosperms, establishment of symmetry in plants, seed formation. (3)
5. Developmental routes of apomixis, polyembryony and its molecular aspects. (4)

**Group B**
**Plant Breeding & Biometry**

**TEE points: 40** **Classes/ Semester: 40**

1. Breeding methods: Introduction and conservation of germplasm, mass selection, pure line selection, clonal selection, hybridization, selection after hybridization (bulk, pedigree, recurrent), heterosis & inbreeding depression. (3)
2. An outline of mutation and polyploid breeding. (3)
3. Cytogenetics & breeding practices of crop plants: rice, maize, potato (4)
4. An outline of breeding methods for development of disease resistance (3)
5. Molecular marker assisted breeding – an outline (2)
6. Population samples, sampling methods. (2)
7. Frequency distribution, histogram, normal curve, mean, median, mode, variance, standard deviation, standard error. (3)
8. Probability & test of significance (Student & paired t) $\chi^2$ test (detection of segregation ratio & linkage, test of independence & heterogeneity), analysis of variance (F test) CD, genetic advance, heritability estimation. (11)
9. Correlation & regression. (5)
10. Design of experiments: general principles of field trails, randomized blocks, latin square, split plot designs, layout of breeding experiment. (4)

**Practical Course**
**BOHCP2.3**
**(Based on BOHCT2.3 – Plant Embryology, Plant Breeding & Biometry)**

**Points: 25** **3 hours/ week**

1. Microsporogenesis and development of male gametophyte (pollen) and pollinia.
2. Megasporogenesis and development of female gametophyte.
3. Observation on types of endosperm, dissection and isolation of endosperm.
4. Observation or stages of embryo development, dissection and isolation of developing embryo.
5. Effect of different concentration and combination of sucrose, boric acid on pollen germination and pollen tube growth.
6. Pollen-pistil interaction in angiosperms.
7. Hybridization technique (anthesis, emasculation, pollination).
8. Studies on genetic variability in crop plants utilizing biometrical approaches t-test, F analysis, distribution patterns.
9. Designing of breeding experiments.
10. Determination of genetic segregation involved qualitative traits in plants.
11. Correlation and regression analysis for yield contributing traits in crop plants.
12. Seed germinability and viability test.

**Note: Regularly checked laboratory records should be submitted in a standard manner at the time of TEE.**

***** ***** *****

| Course | Subject | Points | Credits | Hrs./Wk. |
|---|---|---|---|---|
| **BOHCT2.4** | **Palaeobotany, Palynology, Plant Anatomy** | **75** | **3** | **4** |
| **BOHCP2.4** | **Practical based on BOHCT2.4** | **25** | **1** | **3** |
| **TOTAL (Group A + B + C)** | | **100** | **4** | **7** |

**EVALUATION SCHEME - THEORY:** **Internal Assessment (15) + Term End Examination (60)**
**TEE: Group A (20 points) + Group B (20 points) + Group C (20 points)**

**PRACTICAL:** **Internal Assessment (5) + Term End Examination (20)**

**Theoretical course**
**BOHCT2.4**

**Group A**
**Palaeobotany**

**TEE points: 20** **Classes/ Semester: 20**

1. Introduction: Definition and application. (2)
2. Preservation of plants as fossils: Definition; taphonomy; environment for fossilization; modes of preservation; types; major rock types, rock cycle and rocks containing Fossils; systematics, reconstruction and nomenclature. (3)
3. Geologic Time: Geologic timescale, relative *vs*. numerical age, physical and biological principles for defining relative and numerical age. (2)
4. Early Life: The origin of earth, earliest environment, theories on origin of life, evidences for the origin of life - prokaryotes, evolution of eukaryotes and fossil records, diversified life - algae and fungi. (3)
5. Terrestrialization of plants: Geologic time, environment, vegetative and reproductive adaptations to land dwelling, fossil evidences - transitional plants with land adaptive features, early non vascular land plants (bryophytes), early vascular land plants (pteridophytes). (2)
6. Early vascular plants to early spore producing trees (arborescent pteridophytes & progymnosperms): Geologic time, environment, advancement in plant adaptive features for land dwelling with fossil evidences. (3)
7. Early spore producing trees to early seed producing trees (gymnosperms): From isospores to free sporing heterospores, origin of ovule, hydrasperman reproduction with fossil evidences. (3)
8. Origin and evolution of flowering plants (angiosperms): Geologic time, evolutionary trends - angiosperm derived characteristics, fossil evidences for early flowering plants, place of origin, radiation, phylogeny. (2)

**Group B**
**Palynology**

**TEE points: 20** **Classes/ Semester: 20**

1. Spore-pollen morphology: units, polarity, symmetry, shape, size, aperture; NPC system for numerical expression of apertural details; harmomegathic mechanism; evolution of aperture types. (5)
2. Sporoderm: stratification & sculptures; LO- analysis; pollen wall evolution. (2)
3. Pollen Wall: Development; Ubisch body; sporopollenin; adaptive significance of pollen wall architecture. (3)
4. Extraexinous wall materials: pollen connecting threads, perine, pollen-kit. (3)
5. Natural spore/pollen traps: types, their implications in floristic & environment reconstruction. (2)
6. Branches of Palynology & their Application: Branches of palynology; palynology in taxonomic & phylogenetic deductions; palynology in academic & applied aspects including melissopalynology, medical palynology, forensic palynology, entomopalynology & copropalynology. (5)

**Group C**
**Plant Anatomy**

**TEE points: 20** **Classes/ Semester: 20**

1. Meristems and differentiation: meristems and growth of the plant, differentiation of primary and secondary plant body: epidermis: stomatal ontogeny, cuticle and epidermal appendages; secretory structure (6)
2. Phylogeny and evolution of vascular and mechanical tissue elements: origin and development of sclereids and fibres, phylogeny of xylem and phloem elements, wood anatomy: vascular cambium and its seasonal activity. (6)
3. Anatomical variations with ecology: leaf and root anatomy in ecological perspectives; hydraulic architecture of plant (5)
4. Anatomy in applied science: anatomy and pollution, anatomy in forensic science, archaeology and climatology. (3)

**Practical Course**

**BOHCP2.4**

**(Based on BOHCT2.4 – Palaeobotany, Palynology, Plant Anatomy)**

**Points: 25** **3 hours/ week**

1. Studies of types of fossils, modes of preservation, rocks and tectonic features of rocks.
2. Systematic studies of available plants fossils through ages.
3. Demonstration of extraction of microfossils from peat, lignite and coal samples, quantitative and qualitative palaeopalynological study of macerated peat, lignite and coal samples and interpretation of data on stratigraphic age and environment of deposition.
4. Preparation of palynological slides by acetolysis method from fresh and dry spore and pollen samples.
5. Studies of different types of spores (pteridophyte) and pollen grains (gymnosperms and angiosperms), their shape, aperture and sculpture.
6. Preparation of honey samples and its characterization for melittopalynological study.
7. Preparation of natural spore-pollen traps (at least two) for palynology.
8. Study of trichomes, sclereids, fibres, tracheids and vessels
9. Study of laticifer
10. Leaf anatomy of xeromorphic leaves, sun and shade leaves, succulent leaves
11. TS, TLS and RLS of woody plant

**Note: Regularly checked laboratory records, specimens collected during compulsory field works and permanent slides prepared during practical classes should be submitted in a standard manner along with Field Note Books at the time of TEE.**

***** ***** *****

**SEMESTER III**

| Course | Subject | Points | Credits | Hrs./Wk. |
|---|---|---|---|---|
| **BOHCT3.1** | **Principles of Plant Pathology & Crop Protection** | **75** | **3** | **4** |
| **BOHCP3.1** | **Practical based on BOHCT3.1** | **25** | **1** | **3** |
| **TOTAL** | | **100** | **4** | **7** |

**EVALUATION SCHEME - THEORY:** Internal Assessment (15) + Term End Examination (60)
TEE: 60 points
**PRACTICAL:** Internal Assessment (5) + Term End Examination (20)

**Theoretical course**
**BOHCT3.1**

**Principles of Plant Pathology & Crop Protection**

**TEE points: 60** **Classes/ Semester: 60**

1. Historical and developmental aspects of plant pathology (2)
2. Production, liberation and dispersal of inoculum, inoculum potential; factors affecting inoculum potential (4)
3. Host-pathogen interaction: penetration and disease development, role of cell-wall degrading enzymes and toxins, recognition mechanism and signal transduction during plant-pathogen interaction (10)
4. Defense mechanisms of plants against infection: Pre-existing structural and biochemical defense, induced structural and biochemical defense, hypersensitive reaction, phytoalexins, PR proteins, systemic acquired resistance, induced systemic resistance; Gene for gene hypothesis; concept of horizontal and vertical resistance (15)
5. Physiological (photosynthesis, respiration, translocation of water and nutrients) and molecular (protein and nucleic acid) changes in diseased plants (5)
6. Predisposition, survival of pathogen in nature and its spread, disease epidemics (2)
7. Principles of plant disease control: exclusion, eradication, protection and therapy (2)
8. Strategies of plant disease management with special emphasis on cultural and biological management; plant quarantine; integrated pest management (4)
9. Fungicides: types and uses (1)
10. Study of some plant diseases with reference to symptoms, etiology and control measures: (15)
    i. Fungal diseases: wart and early blight of potato, downy mildew of grapes, powdery mildew of rose, white rust of crucifers, peach leaf curl, linseed rust, smut and red rot of sugarcane, Tikka disease of groundnut, Panama disease (Fusarium wilt) of banana, blast and sheath blight of paddy
    ii. Bacterial diseases: leaf blight of paddy, Moko disease (bacterial wilt) of banana
    iii. Viral diseases: Tungro viral disease of paddy, mosaic of potato
    iv. Disease caused by nematode: root knot of tomato
    v. Disease caused by mycoplasma-like organism: little leaf of brinjal

**Practical Course**
**BOHCP3.1**
**(Based on BOHCT3.1 – Principles of Plant Pathology & Crop Protection)**

**Points: 25** **3 hours/ week**

1. Sterilization and incubation: principles and uses of instruments
2. Culture media and their preparation
3. Preparation of stabs, slants and pouring of plates
4. Isolation of pathogen from diseased tissues (leaf, stem and fruit)
5. Preparation of pure culture and sub-culturing
6. Inoculation of tuber, stem and fruit
7. Assay of pre-existing toxic compounds in host plant
8. Measurement of enzyme activity in pathogen

9. Assay of fungicides by spore germination test
10. Symptomology and histopathology of some common diseases with diagnostic characteristics in available diseased plant specimens

**Note: Regularly checked laboratory records, permanent slides prepared during practical classes, preserved and dried specimens collected during field works should be submitted at the time of term-end examination.**

***** ***** *****

| Course | Subject | Points | Credits | Hrs./Wk. |
|---|---|---|---|---|
| **BOHCT3.2 (Group A + B)** | **Plant Molecular Biology & Biotechnology** | **75** | **3** | **4** |
| **BOHCP3.2** | **Practical based on BOHCT3.2** | **25** | **1** | **3** |
| **TOTAL** | | **100** | **4** | **7** |
| **EVALUATION SCHEME - THEORY:** | **Internal Assessment (15) + Term End Examination (60)** | | | |
| | **TEE: Group A (30 points) + Group B (30 points)** | | | |
| **PRACTICAL:** | **Internal Assessment (5) + Term End Examination (20)** | | | |

## Theoretical course
## BOHCT3.2

### Group A
### Plant Molecular Biology

**TEE points: 30** **Classes/ Semester: 30**

1. Protein structure and function, amino acid sequencing, protein analysis (electrophoresis, s-value crystallography, mass spectrophotometry, x-ray crystallography). (5)
2. Protein sorting: protein targeting in organelles. (3)
3. Nucleic acid: Structure, chemical and physical properties, nuclear, chloroplast and mitochondrial genome. (5)
4. Recombinant DNA Technology: Restriction enzymes, cloning vectors, construction of recombinant DNA. (5)
5. Biology of RNA types: Ribosomal RNA, transfer RNA and messenger RNA; post m-RNA modifications, RNA splicing, Regulatory RNAs and related phenomenon: si-RNA, mi-RNA, Ribozyme, antisense RNA, RNAi, Riboswitch. (6)
6. Blotting techniques: Southern, Northern and Western Blot; DNA fingerprinting, DNA foot printing, basic idea of proteomics and genomics, c-DNA and genomic library. (3)
7. Bioinformatics: Definition, importance, constituents, application in genomics. (3)

### Group B
### Biotechnology

**TEE points: 30** **Classes/ Semester: 30**

1. Plant tissue culture: Cellular totipotency; organogenesis, somatic embryogenesis, Role of SERK and LEC genes during SE; haploidy and DH populations in crop improvement. (4)

2. Genetic transformation: *Agrobacterium* mediated (co-culture, *in planta*, agroinfection); Direct method (PEG, electroporation, particle gun method); Reporter genes- screenable and selectable markers. (3)
3. Biotechnological applications for crop management: Approaches to improve shelf life of fruits and vegetables; herbicide resistance; insect and pest management. (2)
4. Secondary metabolite production in plant cultures: Types of secondary metabolites; culture systems used for secondary metabolite production; improving secondary metabolite production in culture; hairy root culture. (3)
5. Micropropagation: Production of virus free plants, virus free assessment methods, genetic assessment by RAPD and ISSR markers, certification for quality plants. (3)
6. Fermentation technology: application of fermentation; batch, fed batch and their continuous cultures of microbes; Bioreactors: Principles and their design; microbial strain improvement. (4)
7. Immobilization of microbial enzymes and whole cells and their applications in industries. (2)
8. Microbes as food and in food processing, single cell protein. (3)
9. Biofertilizers and biopesticides in agriculture. (2)
10. Environmental biotechnology: Treatment of waste & waste water; bioremediation. (2)
11. Regulatory issues in biotechnology: Intellectual property rights (IPR): Patents, plant variety protections & geographical indications, WTO & TRIPPS, Bio safety and Food safety of GMO - a brief outline. (2)

## Practical Course

**BOHCP3.2**

**(Based on BOHCT3.2 –Plant Molecular Biology & Biotechnology)**

**Points: 25** **3 hours/ week**

1. Isolation & purification of plant proteins by salting out process.
2. Gel electrophoresis of protein.
3. Estimation of protein by Lowry's method.
4. Isolation and purification of DNA and RNA.
5. Estimation of DNA and RNA.
6. Isolation of chloroplast, Determination of Hill activity.
7. Isolation and purification of an enzyme.
8. Determination of $K_m$ of enzyme.
9. Demonstration on agarose gel electrophoresis technique for DNA.
10. Plant tissue culture techniques: Media preparations; methods of sterilization.
11. Culture of explants (shoot tips, nodal segments, embryo).
12. Callus and cell suspension culture technique.
13. Measurement of plant cell growth (packed cell volume)
14. Seed culture technique: Production of synthetic seed (demonstration).
15. Detection of fungal products - organic acids, alcohol & cellulose enzyme.
16. Selection of different species of *Aspergillus* for better amylase production.
17. Mushroom cultivation (demonstration).

**Note: Regularly checked laboratory records, permanent slides prepared during practical classes, preserved and dried specimens collected during field works should be submitted at the time of term-end examination.**

*****  *****  *****

| Course | Subject | Points | Credits | Hrs./Wk. |
|---|---|---|---|---|
| **BOHCT3.3** | **Plant Ecology, Biodiversity & Conservation** | **75** | **3** | **4** |
| **BOHCP3.3** | **Practical based on BOHCT3.3** | **25** | **1** | **3** |
| **TOTAL** | | **100** | **4** | **7** |

**EVALUATION SCHEME - THEORY:** Internal Assessment (15) + Term End Examination (60)
TEE: 60 points
**PRACTICAL:** Internal Assessment (5) + Term End Examination (20)

## Theoretical course
## BOHCT3.3

## Plant Ecology, Biodiversity & Conservation

**TEE points: 60** **Classes/ Semester: 60**

1. Introduction to Ecology: scope and nature of plant ecology. (3)
2. Approaches in ecological studies: formulating hypothesis; theoretical ecological models; probabilistic ecological models; statistical approaches; phylogenetic approaches; remote sensing; climate diagrams. (6)
3. Abiotic environment: variables in action; influence of abiotic environment on distribution and abundance of plants. (3)
4. Biotic environment: levels of organization of organisms in ecology; plant interactions. (2)
5. Habitat and Niche: concept of habitat and niche; niche width and overlap; fundamental and realized niche; competitive exclusion principle; extinction; resource partitioning; character displacement; speciation. (5)
6. Population ecology: characteristics of population; population growth curves, population regulation, life history strategies (*r* and *K* selection); metapopulation, habitat fragmentation, demes, source-sink model. (7)
7. Community ecology: concepts of community, assemblage and guilds; open and closed communities, ecotone; community continuum concept; community structure; measures of community structure – diversity indices, similarity measures, food web analysis; succession - types, mechanisms, concept of climax. (8)
8. Ecosystem ecology: concept of ecosystem, disturbance (natural and anthropogenic) and their impact on plant ecology; invasive plant species; resistance and resilience of ecosystems. (4)
9. Biogeographical ecology: terrestrial ecology; wetland and freshwater ecology; coastal and marine ecology; major biogeographical zones of India. (6)
10. Biodiversity: Concept, kinds/ levels, importance, methods of study, protection from depletion; Mega - diversity and Hotspots. (6)
11. Threats to Biodiversity: Causes of threats; Concepts of rare, vulnerable, endangered and threatened plants (IUCN categories). (3)
12. Conservation: Types of conservation - *in-situ* conservation: Biosphere Reserve, Wildlife Sanctuaries, National Parks, World Heritage Sites; Concept and types of Protected Areas

Networks; *ex-situ* conservation: principles, methods, definition, aims and activities of W.W.F., Red Data Book, MAB, CITES, Role of Botanic Gardens and Gene Banks. (8)

**Practical Course**
**BOHCP3.3**
**(Based on BOHCT3.3 – Plant Ecology, Biodiversity & Conservation)**

**Points: 25** **3 hours/ week**

1. Quadrat Analysis:
   a. Determination of minimum quadrat size by species-area curve.
   b. Determination of minimum number of quadrats to be laid down.
2. Quantitative assessment of communities:
   a. Determination of frequency, density and abundance of a terrestrial herbaceous plant community, preparation of frequency diagram and comparison of the same with the Normal Frequency Diagram.
   b. (The species recorded from the field should be submitted as herbarium specimens).
   c. Study of an aquatic/ wetland plant community/ phytoplankton community for assessment of diversity by measurement of species diversity index.
   d. (The aquatic/ wetland species recorded from the field should be submitted as wet specimens).
3. Qualitative assessment of communities:
   a. Comparison of three different plant communities using different similarity coefficients.
4. Exercise in designing ecological experiments:
   a. Formulation of hypotheses/ research questions to explain any given natural phenomenon and designing an experiment based on approaches in ecology to test the same.
5. Field visit: One field excursion to any of the following ecosystems: (a) terrestrial (forest/ grassland) or (b) aquatic (freshwater/ estuarine). Only Field Note Books to be submitted.

**Note: Regularly checked laboratory records, dried and wet specimens collected during field works should be submitted in a proper way at the time of term-end examination.**

***** ***** *****

**SOFT CORE THEORY COURSES** (Any **two** to be chosen from following Courses)

| | |
|---|---|
| **BOSCT3.1 Environmental Biology** | **BOSCT3.4 Medical Mycology** |
| **BOSCT3.2 Forensic Botany** | **BOSCT3.5 Economic Botany & Pharmacognosy** |
| **BOSCT3.3 Industrial Microbiology** | **BOSCT3.6 Stress Physiology** |

| Course | Course Name | Points | Credits | Hrs./Wk. |
|---|---|---|---|---|
| **BOSCT3.1** | **Environmental Biology** | **50** | **2** | **2** |
| **EVALUATION SCHEME - THEORY:** | **Internal Assessment (10) + Term End Examination (40)**<br>**TEE: 40 points** | | | |

**Theoretical course**
**BOSCT3.1**

**Environmental Biology**

**TEE points: 40** **Classes/ Semester: 40**

1. An introduction to environmental biology. (1)
2. The biosphere- The terrestrial biomes and the aquatic biomes. (3)
3. Basic ecological concepts and processes- Energy in ecosystem, food chain and food web. (4)
4. Biogeochemical cycles- Concept, gaseous and sedimentary cycle, nitrogen, sulphur and phosphorous cycles. (4)
5. Environmental pollution- Pollution and pollutant- Concept, definition and characteristics (20)
   a. Air pollution- Source and types of air pollutant and their chemistry, photochemical reactions, green house and global warming, $O_3$ depletion, acid rain, air pollutant in India
   b. Water pollution- Source and type of water pollution, effect of water pollution on ecosystem, heavy metals and their effect on biota, nuclear pollution and thermal pollution
   c. Electronic waste (e waste), sources and types, constituents of e waste, recycling of e waste, impact of e waste on environment and its management
   d. Soil pollution- Sources and classes of soil pollutants and their environmental effects, solid waste-pollution and disposal problems, waste- effect disposal and management
   e. Pesticides, classification, chemical pollution, effect on living organisms.
6. Environmental toxicology- Principles and mechanisms. (4)
7. Environmental laws and policies. (4)

***** ***** *****

| Course | Course Name | Points | Credits | Hrs./Wk. |
|---|---|---|---|---|
| **BOSCT3.2** | **Forensic Botany** | **50** | **2** | **2** |
| **EVALUATION SCHEME - THEORY:** | **Internal Assessment (10) + Term End Examination (40)**<br>**TEE: 40 points** | | | |

**Theoretical course**
**BOSCT3.2**

**Forensic Botany**

**TEE points: 40** **Classes/ Semester: 40**

1. Introduction: Introduction to forensic botany (3)
2. Collection and preservation of botanical evidences: Botanical samples, outdoor crime scene consideration (5)
3. Analysis of samples: Plant anatomy; pollen analysis; DNA analysis; plant DNA typing. (12)
4. Classic forensic botany cases: Case histories by using Plant anatomy and systematic, Palynology, Plant ecology, Limnology, Plant Molecular Biology and DNA, Drug enforcement and DNA. (20)

***** ***** *****

| Course | Course Name | Points | Credits | Hrs./Wk. |
|---|---|---|---|---|
| **BOSCT3.3** | **Industrial Microbiology** | **50** | **2** | **2** |
| **EVALUATION SCHEME - THEORY:** | **Internal Assessment (10) + Term End Examination (40)**<br>**TEE: 40 points** | | | |

**Theoretical course**

**BOSCT3.3**

**Industrial Microbiology**

**TEE points: 40** **Classes/ Semester: 40**

1. Scope of Industrial Microbiology:
   a. Definition and use of the term 'fermentation'. (1)
   b. History (An Art from the Past, a Skill for the Future). (1)
   c. Organizational set-up in an industrial microbiology establishment. (1)
   d. Upstream processing (USP) and downstream processing (DSP). (1)
   e. A typical bioprocess: introduction, advantages and limitations. (1)
   f. Industrial fermentation products and their producer microorganisms. (1)
   g. Patents and Intellectual Property Rights. (2)
2. Industrial Microorganisms:
   a. Characteristics of important microbes used in Industrial Microbiology. (1)
   b. Isolation of suitable producer microorganisms from the environment. (1)
   c. Concept and examples of microorganisms classified as Generally Regarded As Safe (GRAS) (2)
   d. Industrial producer strains and strain improvement. (2)
   e. Use of mutants/ Genetically Modified Microorganisms (GMM) as against Wild type isolates for production. (2)
   f. Aseptic and non-aseptic fermentations. (1)
   g. Fermentation types according to the organization of the biological system (suspended and support culture) (4)
3. Fermenter: Different types of fermenter: Stirred Tank, Bubble column, Air Lift, Packed-bed etc.(5)
4. Industrial Production: Industrial production of (using most common and low-cost raw materials) Ethyl Alcohol, Acetic Acid, Penicillin, Vitamin B12, Amylase, Lysine, Streptomycin. (14)

***** ***** *****

| Course | Course Name | Points | Credits | Hrs./Wk. |
|---|---|---|---|---|
| **BOSCT3.4** | **Medical Mycology** | **50** | **2** | **2** |
| **EVALUATION SCHEME - THEORY:** | **Internal Assessment (10) + Term End Examination (40)**<br>**TEE: 40 points** | | | |

**Theoretical course**

**BOSCT3.4**

**Medical Mycology**

**TEE points: 40** **Classes/ Semester: 40**

1. Fungi as human pathogens, host-pathogen interaction, pathogenecity factors (3)
2. Mycoses: types, symptoms and treatment (9)
3. Diseases caused by aflatoxin and other fungal toxins and their impact on human health (9)
4. Mycetismus and mushroom poisoning (8)
5. Fungi as allergens (7)
6. Fungi and its products used for therapeutic purposes (4)

***** ***** *****

| Course | Course Name | Points | Credits | Hrs./Wk. |
|---|---|---|---|---|
| **BOSCT3.5** | **Economic Botany and Pharmacognosy** | **50** | **2** | **2** |
| **EVALUATION SCHEME - THEORY:** | **Internal Assessment (10) + Term End Examination (40)**<br>**TEE: 40 points** | | | |

**Theoretical course**
**BOSCT3.5**

**Economic Botany and Pharmacognosy**

**TEE points: 40** **Classes/ Semester: 40**

1. Centre of origin of cultivated plants; Indian centre of wild plant genetic resources. Botany and uses of fodder, fiber yielding, medicinal and aromatic plants. (3)
2. An accounts and uses of the following plant resources: Timber, non-wood forest products, bamboo and cane; paper yielding plants; sources of following plant products - resin, gum, tannin, dye, rubber and latex. (10)
3. Non - medicinal poisonous and toxic plants: Preliminary accounts of the plants and their effect: hallucinogenic, allergenic, teratogenic and carcinogenic. (4)
4. Bioprospecting: antimicrobial, antifungal, antiviral and anti-cancerous plants. (3)
5. Plants used for pollution control: Methods of control and examples. Mineral indicating plants.(2)
6. Pharmacognosy: Definition and scope. (1)
7. Pharmacopoeias: Definition and examples. (1)
8. Classification of plant drugs: Morphological and chemical (brief knowledge of different categories of drug plants producing carbohydrates, alkaloids, essential oils, resins and glycosides). (6)
9. Concise account of macro - micro morphological features, constituents, adulterants, allied drugs and uses of the following plants - *Digitalis* (leaf drug); *Cinchona* (bark drug); *Cephaelis* (root and rhizome drugs); *Rauvolfia* (root and rhizome drugs); *Strychnos* (seed drug); *Syzygium* (flower drug) and *Coriandrum* (fruit drug). (10)

***** ***** *****

| Course | Course Name | Points | Credits | Hrs./Wk. |
|---|---|---|---|---|
| **BOSCT3.6** | **Stress Physiology** | **50** | **2** | **2** |
| **EVALUATION SCHEME - THEORY:** | **Internal Assessment (10) + Term End Examination (40)**<br>**TEE: 40 points** | | | |

**Theoretical course**
**BOSCT3.6**

**Stress Physiology**

**TEE points: 40** **Classes/ Semester: 40**

1. Definition and categories of abiotic stress: water stress and their impact on plant's life with regards to productivity. (4)
2. Salinity stress and gene expression. (3)
3. Oxidative stress and antioxidation strategies in plants and their cellular regulation. (6)
4. Transcriptome analysis in stress mediated responses to plants. (5)
5. Analysis of DNA markers in assisted breeding for stress tolerance. (3)
6. Techniques in validation of stress tolerance in plants. (4)
7. Temperature stress and HSPs structure and functions in plants. (4)
8. Development of transgenic for stress tolerance. (5)
9. Crop designing for stress tolerance and climate resilient plants. (6)

***** ***** *****

**ELECTIVE PAPER: Elective Paper allotment and classes will start from 3rd Semester**

Any **one** single combination of Course – I & Course – II from the following

| | | |
|---|---|---|
| Course - I | BOECT4.1 | Genetics, Molecular Genetics, Biometry & Plant Breeding |
| Course - II | BOECT4.2 | Genetics, Molecular Genetics, Biometry & Plant Breeding |
| Course - I | BOECT4.3 | Microbiology |
| Course - II | BOECT4.4 | Microbiology |
| Course - I | BOECT4.5 | Mycology & Plant Pathology |
| Course - II | BOECT4.6 | Mycology & Plant Pathology |
| Course - I | BOECT4.7 | Phycology |
| Course - II | BOECT4.8 | Phycology |
| Course - I | BOECT4.9 | Plant Physiology, Plant Biochemistry & Plant Molecular Biology |
| Course - II | BOECT4.10 | Plant Physiology, Plant Biochemistry & Plant Molecular Biology |
| Course - I | BOECT4.11 | Pteridology & Palaeobotany |
| Course - II | BOECT4.12 | Pteridology & Palaeobotany |
| Course - I | BOECT4.13 | Taxonomy of Angiosperms & Biosystematics |
| Course - II | BOECT4.14 | Taxonomy of Angiosperms & Biosystematics |

**SEMESTER IV**

| Course | Subject | Points | Credits | Hrs./Wk. |
|---|---|---|---|---|
| **BOET4.1** | Genetics, Molecular Genetics, Biometry & Plant Breeding (Course - I) | **100** | **4** | **6** |
| **BOET4.2** | Genetics, Molecular Genetics, Biometry & Plant Breeding (Course - II) | **100** | **4** | **6** |
| **BOEP4.1** | Practical based on BOET4.1 & BOET4.2 | **100** | **4** | **12** |
| **BOEPW4.1** | Project/ Review | **50** | **2** | **4** |
| **TOTAL (BOET4.1 + BOET4.2 + BOEP4.1 + BOEPW4.1)** | | **350** | **14** | **28** |

**EVALUATION SCHEME:**
**THEORY (BOET4.1):** Internal Assessment (20 points) + Term End Examination (80 points)
**THEORY (BOET4.2):** Internal Assessment (20 points) + Term End Examination (80 points)
**PRACTICAL:** Internal Assessment (20) + Term End Examination (80)

**Theoretical course**
**BOET4.1**

**Genetics & Molecular Genetics (Course – I)**

**TEE points: 80** **Classes/ Semester: 80**

1. Genetic engineering: Restriction enzymes; cloning vectors (plasmids, cosmid, phagmids, YAC, BAC); cloning strategies; polymerase chain reaction; sequencing strategies; DNA gel electrophoresis; blotting techniques; c-DNA library; DNA foot printing; DNA finger printing. (10)

2. Transgenics: Development strategies; Transgenics in relation to insect, herbicide, stress resistance; delayed fruit ripening; golden rice; vaccine development; male sterility; molecular farming; flower colour; terminator gene sequence. (12)
3. Genetic recombination: Molecular basis of chromosome pairing; Rec BCD pathway; double strand model in yeast; gene conversion in bread mold; site specific recombination. (5)
4. Genetic diseases. Pedigree analysis. Gene therapy and genetic counselling. (4)
5. Gene knockout mutation in reference to mice and yeast models. (3)
6. Gene regulation at the level of transcription and translation in eukaryotes. (10)
7. Dosage compensation. (3)
8. RNA biology: RNA editing and evolutionary significance; antisense RNA technology and gene silencing; ribozyme; different categories of small non coding RNAs; biogenesis and functions of small RNAs in posttranscriptional gene silencing; application of RNAi in crop quality improvement. (5)
9. Cancer: Properties of cancer cells. Transfection test. Genetic basis of cancer. Characterization of $p^{53}$ and its role in regulation of cancer. Role of gene mutation, reciprocal translocation, insertion of retroviral genome and constitutive amplification in cancer development; environmental carcinogenesis; therapy and side effects. (10)
10. T-DNA technology: T-DNA transfer, disarming of T-DNA, cointegrates; direct and indirect methods of gene transfer. Binary vector. Shuttle vector. (4)
11. Cell Signaling: Intracellular and cell surface; receptor proteins: ion channel linked, G-protein linked and enzyme linked. (3)
12. Genomics: Structural genomics, molecular markers and mapping of genome using - RFLP, RAPD, AFLP, $EST_S$ and micro-satellite markers; chromosome walking; Functional genomics: DNA microarray and chip technology; a brief idea on Human Genome Project. (6)
13. Proteomics: Concept of proteome; basic principles of 2-DE; advantages and limitations of 2-DE; gel free proteomics; mass spectrometry. (5)

**Theoretical course**
**BOET4.2**

**Plant Breeding & Biometry (Course – II)**

**TEE points: 80** **Classes/ Semester: 80**

1. Male Sterility: Induction, characterization and application. (10)
2. Self incompatibility: Types, significance; genetic and molecular basis; overcoming self incompatibility. (10)
3. Polyploidy in angiosperms - genetic insight to the phenomenon. (5)
3. Distant hybridization: Barriers and achievements. Bridge species. (5)
4. Back cross method of breeding: Significance and limitations; multiline concept. (5)
5. Molecular marker assisted breeding. Molecular markers in genome and QTL analyses. (5)
6. Breeding and biotechnological approaches to improve nutritional quality of food crops. (5)
7. Biotechnological approaches for improving abiotic stress tolerance in plats. (10)
8. Genetics of disease resistance in crop plants. (5)
9. Concept of heritability. (2)

10. Use of biometrical tests in genetics and breeding with special reference to path-coefficient analysis. (18)

**Practical Course**

**BOEP4.1**

**(Based on BOET4.1 & BOET4.2 - Genetics, Molecular Genetics, Biometry & Plant Breeding)**

**Points: 100** **12 hours/ week**

1. Comparative study of karyotypes of selected plant materials (both from root tips and leaf tips).
2. Scanning of chromosome aberrations (mitotic and meiotic).
3. Chromosomes - Nucleolus relationship, nucleolar staining.
4. Demonstration of alkaline phosphate activity on plant chromosome.
5. Localization of DNA *in situ*.
6. Extraction, identification and estimation of macromolecules DNA, RNA and protein.
7. Gel electrophoresis study of DNA and protein.
8. Amplification of extracted DNA from plant material.
9. Micropropagation and induction of embryogenesis (somatic and gametic).
10. Cell suspension culture technique and induction of organogenesis and embryogenesis.
11. Effect mutagenic agent on plant system to note chromosomal irregularities.
12. Isolation and analysis of secondary metabolite in vitro.
13. Study of chromosomes from tissue culture generated plants
14. Data analysis using biometrical methods.
15. Determination of $T_m$ value and cot-value.

**Note: Regularly checked laboratory records should be submitted at the time of term-end examination.**

***** ***** *****

| Course | Subject | Points | Credits | Hrs./Wk. |
|---|---|---|---|---|
| **BOET4.3** | Microbiology (Course - I) | **100** | **4** | **6** |
| **BOET4.4** | Microbiology (Course - II) | **100** | **4** | **6** |
| **BOEP4.2** | Practical based on BOET4.3 & BOET4.4 | **100** | **4** | **12** |
| **BOEPW4.1** | Project/ Review | **50** | **2** | **4** |
| **TOTAL (BOET4.3 + BOET4.4 + BOEP4.2 + BOEPW4.1)** | | **350** | **14** | **28** |

| | | |
|---|---|---|
| **EVALUATION SCHEME:** | **THEORY (BOET4.3):** | **Internal Assessment (20 points) + Term End Examination (80 points)** |
| | **THEORY (BOET4.4):** | **Internal Assessment (20 points) + Term End Examination (80 points)** |
| | **PRACTICAL:** | **Internal Assessment (20) + Term End Examination (80)** |

**Theoretical course**

**BOET4.3**

**Microbiology (Course – I)**

**TEE points: 80** **Classes/ Semester: 80**

1. Environmental Microbiology

a. Microbes in environment – their evolution and diversity, RNA world, evolution of bacterial species- 16s rRNA based Phylogeny (10)
b. Microbial interaction, Biofilm, Biosensor (8)
c. Aeromicrobiology- Assessment of aeromicroflora, microbes as atmospheric pollutant (2)
d. Water microbiology- Assessment of water quality through physiochemical and microbiological parameters (10)
e. Waste water treatment microbiology- Treatment of waste water by microorganisms (6)
f. Soil microbiology- Biotic and abotic factors regulating the population dynamics of soil microflora (10)
g. Microbial biogeochemical cycling- Nitrogen cycle, phosphorus cycle, sulfur cycle (6)
h. Role of microbes in environmental management- microbial bioremediation, role of microorganisms in mineral recovery, microbial bioleaching of metals, bioterrorism (8)
**i.** Microbial desulfurization of coal, degradation of xenobiotics by microorganisms, biodegradation of halocarbons, synthetic polymers, oil, biopolymer. (5)

2. Agriculture microbiology

Microbial exploitation for improvement and crop protection, biopesticides, biofertilizers, bio-composting (5)

3. Clinical microbiology

Air, water, soil and food borne diseases, Venereal diseases. (5)

4. Food microbiology

Micro-organism associated with food; food spoilage; food poisoning and intoxication; food preservation, concept of probiotics. (5)

**Theoretical course**
**BOET4.4**

**Microbiology (Course – II)**

**TEE points: 80** **Classes/ Semester: 80**

1. Microbial genetics (30)

Genomic structure and organization of virus and bacteria; Bacterial genome replication and cell cycle; Strategies of cell division in bacteria; Gene regulation in bacteria; Transformation, transduction and conjugation in bacteria; Molecular basis of regulation of lytic and lysogenic pathway in Virus, Virus-induced cell transformation and cancer; Gene knockout and knockdown in bacteria.

2. Industrial microbiology (20)

Industrially important microbial strains and its method of improvement; Bioreactors-Stirred tank, bubble column, Airlift and photobioreacter; Industrial production of ethanol, Acetone-butanol, Vinegar, Penicillin, Vitamin B12, Amylase, Lysine, Cheese, Interferon

3. Immunology (30)

Organs and tissue associated with immune system; Cell mediated and humoral immunity, MHC, Cytokines; Antigen, Immunoglobulin, Antibody generation, Adjuvant; monoclonal and Polyclonal antibodies, Hypersensitivity, Vaccines, Immune response during Tuberculosis and AIDS; ELISA, RIA, Immunofluorescence & Immunoprecipitation.

**Practical Course**

**BOEP4.2**

**(Based on BOET4.3 & BOET4.4 - Microbiology)**

**Points: 100** **12 hours/ week**

1. Isolation and characterization of bacteria from different habitat.
2. Growth study of *Escherichia coli*/ *Staphylococcus aureus* in presence of various inhibitors/ stimulators in the medium.
3. Determination of potability of water-MPN method.
4. Isolation of root nodule bacteria, their characterization and induction for root hair curling and artificial nodulation.
5. Isolation of phosphate solubulizing, cellulose degrading, nitrogen fixing, IAA producing bacteria from soil.
6. Determination of phenol coeffiicient of different common disinfactants.
7. Microbial quality asessment of salad vegetables.
8. Determination of MIC of different chemicals for inhibition of bacteria growth.
9. Isolation and identification of *Escherichia coli,* fecal *E.coli* and *Salmonella* from domestic water and scoring of antibiotic resistant cells present in the population.
10. Isolation of bacterial DNA and its quantification by chemical method.
11. Induced mutagenesis and selection of mutants; replica planting technique.
12. Industrial/ research institute visit.

***** ***** *****

| Course | Subject | Points | Credits | Hrs./Wk. |
|---|---|---|---|---|
| **BOET4.5** | Mycology and Plant Pathology (Course - I) | **100** | **4** | **6** |
| **BOET4.6** | Mycology and Plant Pathology (Course - II) | **100** | **4** | **6** |
| **BOEP4.3** | Practical based on BOET4.5 & BOET4.6 | **100** | **4** | **12** |
| **BOEPW4.1** | Project/ Review | **50** | **2** | **4** |
| **TOTAL (BOET4.5 + BOET4.6 + BOEP4.3 + BOEPW4.1)** | | **350** | **14** | **28** |

**EVALUATION SCHEME:**
**THEORY (BOET4.5):** Internal Assessment (20 points) + Term End Examination (80 points)
**THEORY (BOET4.6):** Internal Assessment (20 points) + Term End Examination (80 points)
**PRACTICAL:** Internal Assessment (20) + Term End Examination (80)

**Theoretical course**
**BOET4.5**

**Mycology and Plant Pathology (Course – I)**

**TEE points: 80** **Classes/ Semester: 80**

1. Origin of fungi and their interrelationships; phylogeny, affinities and position of fungi in modern systematic (6)
2. Fungal metabolism - chitin synthesis, lysine biosynthesis, pathway and precursors of secondary metabolism (polyketide pathway, isoprenoid pathway, shikimic acid pathway) (6)
3. Genetic variation in fungi: sexual and non-sexual variation and their significance; detection of genetic variation in populations (12)

4. Genomics for fungi: characterization, cloning and expression of heterologous genes in industrially important filamentous fungi (12)
5. Differentiation and sex hormones in fungi: morphogenesis in slime molds, mould-yeast dimorphism, mating and hormonal control (10)
6. Regulation of protein synthesis in fungi; heat shock protein and chaperon, development of thermo-tolerance by heat-shock and other stresses (10)
7. Fungi as saprotrophs; decomposition and decay of wood; biodeterioration (6)
8. Mycoremediation, metal resistance, biosensor (4)
9. Industrial production of citric acid, alcohol, enzymes and antibiotics (8)
10. Culture repositories and methods of preservation of fungal cultures; Mycological databases; GenBank repositories, open source computational and other internet resources for Mycologists and Plant Pathologists; searching and retrieving from databases (6)

**Theoretical course**
**BOET4.6**

**Mycology and Plant Pathology (Course – II)**

**TEE points: 80** **Classes/ Semester: 80**

1. Molecular basis of plant-pathogen interaction: phenomenon of infection, recognition (8)
2. Pathogenesis: mode of action and role of toxins, role of enzymes and growth regulators (10)
3. Molecular aspect of plant disease resistance: role of phenolics, phytoalexins, phytoanticipins, pathogenesis related proteins (classes & functions in plant disease resistance), other antifungal proteins, reactive oxygen species & lipoxygenase; hypersensitive reactions: mechanism of elicitor -receptor concept; systemin; systemic acquired resistance, induced systemic resistance (20)
4. Fungal evasion of host defense (2)
5. Genetics of pathogenecity: major and minor gene resistance, genetics of resistance and susceptibility, genes for virulence and avirulence (8)
6. Epidemiology of plant diseases; disease pyramid: components, measurement and simulation of plant disease epidemics; forecasting and remote sensing (4)
7. Plant disease diagnosis utilizing molecular tools (2)
8. Development of disease resistant variety by mutation, breeding and recombinant DNA technology; RNAi in plant pathology (6)
9. Biological control: current status, constrains and future prospect; Biopesticides (8)
10. Systemic fungicides: their application and mode of action; mechanisms of fungicide resistance; antibiotics used in plant disease control (8)
11. Brief account of seed pathology; post harvest diseases and their control (4)

**Practical Course**

**BOEP4.3**

**(Based on BOET4.5 & BOET4.6 – Mycology and Plant Pathology)**

**Points: 100** **12 hours/ week**

1. Determination of carbohydrate, protein and phenol contents of healthy and diseased tissues
2. Study of factors (pH and temperature) affecting activity of macerating enzymes (pectinase)
3. Study of sensitivity of phytopathogenic bacteria to different antibiotics

4. Isolation of fungi from soil, water, air by culture plate technique.
5. Preparation of monosporous-, polysporous- and tissue- culture
6. Study of hyphal types and hyphal system
7. Study of fungal nuclei
8. Isolation of fungal/plant DNA and its quantification by spectrophotometric method; separation of DNA by agarose gel electrophoresis; amplification of genomic fragment by polymerase chain reaction
9. Induction and bioassay of phytoalexin in host plants
10. Extraction and SDS-PAGE analysis of defense protein in artificially inoculated plants/ induced by abiotic elicitor(s)
11. Assay of metal resistance in fungi
12. Biological control of plant pathogenic fungi by dual culture technique
13. Symptomology and histopathology of some common diseases with diagnostic characteristics in available diseased plant specimens

**Note: Regularly checked laboratory records, permanent slides prepared during practical classes, preserved and dried specimens collected during field works should be submitted at the time of term-end examination.**

***** ***** *****

| Course | Subject | Points | Credits | Hrs./Wk. |
|---|---|---|---|---|
| **BOET4.7** | Phycology (Course - I) | **100** | **4** | **6** |
| **BOET4.8** | Phycology (Course - II) | **100** | **4** | **6** |
| **BOEP4.4** | Practical based on BOET4.7 & BOET4.8 | **100** | **4** | **12** |
| **BOEPW4.1** | Project/ Review | **50** | **2** | **4** |
| **TOTAL (BOET4.7 + BOET4.8 + BOEP4.4 + BOEPW4.1)** | | **350** | **14** | **28** |

**EVALUATION SCHEME:**
**THEORY (BOET4.7):** Internal Assessment (20 points) + Term End Examination (80 points)
**THEORY (BOET4.8):** Internal Assessment (20 points) + Term End Examination (80 points)
**PRACTICAL:** Internal Assessment (20) + Term End Examination (80)

## Theoretical course
## BOET4.7

### Phycology (Course – I)

**TEE points: 80** **Classes/ Semester: 80**

1. Morphology and ultrastructure of the prokaryotic and eukaryotic algal cell: Structural organization and functions of - cell wall, nucleus, mitochondria, Golgi bodies, endoplasmic reticulum, plastids, vacuoles and chloroplast. (8)
2. Evolution and Phylogeny of algal groups: Endosymbiotic theory; Fan-shaped phylogenetic tree; Molecular phylogenetic approaches; Position of algae in the classification system; Evolution of the algal chloroplast. (8)
3. Evolutionary trends and phylogeny of the following algal groups: Prochlorophyta, Glaucophyta, Euglenophyta, Cryptophyta, Heterokontophyta (Chrysophyceae and Eustigmatophyceae); Concepts of Streptophyta; Apicomplexa; Chlorarachniophyta; Chromista. (20)

4. Cyanobacteria: Molecular approach to taxonomy and species concept. (8)
5. Algal genetics: General features of algal genomes; Classical and modern concepts in algal systematics; *Chlamydomonas*: as a model genetic system; *Acetabularia*: for studying gene expression and morphogenesis; Horizontal gene transfer in prokaryotes and eukaryotes. (8)
6. Algal photosynthesis: Light-acquisition, photoprotection, photoinhibition, carbon fixation; Light harvesting pigments – Chlorophylls, Carotenoids and Phycobiliproteins; Chromatic adaptation; Pigment diversity and chemotaxonomy. (15)
7. Algal response to stress: Salinity, desiccation, temperature, light intensity, UV-B radiation; Production and application of stress products. (8)
8. Fossil algae: Major events in the geological time scale during evolution of algae in relation to corresponding environment and other life forms; Fossil history of the algal groups Cyanobacteria, Rhodophyta, Chlorophyta, Dinophyta and Bacillariophyceae. (5)

**Theoretical course**
**BOET4.8**

**Phycology (Course – II)**

**TEE points: 80** **Classes/ Semester: 80**

1. Algal Culture: Axenic culture, Batch, continuous and semi-continuous culture; Outdoor mass culture of microalgae; Photobioreactors; Immobilized algal cells; Culture collections and preservation of algal strains. (6)
2. Algal Pigments: Production and application of algal biocolorants - Phycocyanin, Phycoerythrin, allophycocyanin, Astaxanthin, & beta-carotene along with their commercial potentials. (10)
3. Biogeochemical role: Limiting nutrients; Algae in - carbon cycle, nitrogen cycle, sulfur cycle and silicon cycle; Production of halocarbon compounds. (6)
4. Biotechnological applications: Secondary metabolites of algae; Use of algae as source of pharmaceutical and cosmetic products; Production and application of algal hydrocolloids (agar, alginates, carrageenan); Biodiesel and hydrogen production by algae; Algal techniques for restoration/ maintenance of soil fertility; Algal biofertilizers (BGA biofertilizer and seaweed liquid biofertilizer); Use of algae in nanotechnology. (20)
5. Biotic associations: in food webs, as parasites or pathogens, as epibionts and in mutualistic symbiosis. (6)
6. Phytoplankton ecology: Characteristics of the physical environment; Characteristics of the chemical environment; Growth processes; Loss processes; Nutrient uptake models (Michelis-Menten, Monod & Droop); Competition, spatial heterogeneity, disturbance and coexistence; r and k strategists; Trophic cascades and bio-manipulation. (20)
7. Algal Ecology: macroalgae, periphyton, marine and turf forming algae and terrestrial algae. (5)
8. Algal pollution: Freshwater and marine pollution; monitoring of pollutants; strategies for controlling eutrophication; phycoremediation. (5)
9. Seaweeds and their uses: Historical perspectives and linkages with modern economy and food security. **(2)**

**Practical Course**
**BOEP4.4**
**(Based on BOET4.7 & BOET4.8 - Phycology)**

Points: 100 12 hours/ week

1. Work out of algae samples belonging to major algal groups for identification up to species level and comparative accounts of sets of two samples at generic and species levels.
2. Collection and work out of
   (a) Phytoplankton
   (b) Periphyton
   (c) Epilithon
3. Limnological studies in different water bodies:
   (a) Qualitative and Quantitative estimation of phytoplankton for use as biological assessment of water quality.
   (b) Estimation of DO, BOD, Salinity, Alkalinity, Nitrate and Phosphate for chemical assessment of water quality.
4. Algae immobilization exercise - preparation of algal beads.
5. Extraction and estimation of various algal pigments: chlorophyll, carotenoid and phycocyanin.
6. Algal cytology study.
7. Culturing algae in the laboratory and growth measurements.
8. Field visits for collection of estuarine/ marine/stream algae, their preservation and enumeration.

**Note: Regularly checked laboratory records, permanent slides prepared during practical classes, dry and wet specimens collected during field works should be submitted at the time of term-end examination.**

***** ***** *****

| Course | Subject | Points | Credits | Hrs./Wk. |
|---|---|---|---|---|
| **BOET4.9** | Plant Physiology, Plant Biochemistry & Plant Molecular Biology (Course - I) | **100** | **4** | **6** |
| **BOET4.10** | Plant Physiology, Plant Biochemistry & Plant Molecular Biology (Course - II) | **100** | **4** | **6** |
| **BOEP4.5** | Practical based on BOET4.9 & BOET4.10 | **100** | **4** | **12** |
| **BOEPW4.1** | Project/ Review | **50** | **2** | **4** |
| **TOTAL (BOET4.9 + BOET4.10 + BOEP4.5 + BOEPW4.1)** | | **350** | **14** | **28** |

**EVALUATION SCHEME:** **THEORY (BOET4.9):** Internal Assessment (20 points) + Term End Examination (80 points)
**THEORY (BOET4.10):** Internal Assessment (20 points) + Term End Examination (80points)
**PRACTICAL:** Internal Assessment (20) + Term End Examination (80)

**Theoretical course**
**BOET4.9**

**Plant Physiology, Plant Biochemistry & Plant Molecular Biology (Course – I)**

**TEE points: 80** **Classes/ Semester: 80**

1. Biogenesis of plant products: Biosynthesis of purines & pyrimidines & their nucleotides, phenolics, terpenes, alkaloids, ascorbic acid, carotenoids, chlorophylls, phytosterols. (14)
2. Amino acid metabolism: Oxidation and biosynthesis of proteinogenic amino acids. (8)
3. Protein transport in the chloroplast. (4)
4. Photosystem-I function and physiology. (5)

5. Auxin signaling pathway. (4)
6. Cytokinin signaling in plants. (5)
7. Immunoassay of plant growth regulators. (5)
8. $Ca^{2+}$ signaling in higher plants. (5)
9. One carbon metabolism in higher plants. (6)
10. Organization and regulation of mitochondrial respiration in plants. (6)
11. Alteration of gene expression in higher plants due to environmental stress. (6)
12. ABA- emergence of core signaling system in plants. (6)
13. Assimilation of sulphur, phosphate, cation and oxygen. The energetics of nutrient uptake. (6)

**Theoretical course**
**BOET4.10**

**Plant Physiology, Plant Biochemistry & Plant Molecular Biology (Course – II)**

**TEE points: 80** **Classes/ Semester: 80**

1. Methods of separation, purification and characterization of plant products: chromatography, electrophoresis, centrifugation, spectroscopy, X-ray diffraction. (15)
2. Molecular mechanisms of gibberellin signaling in higher plants. (5)
3. Molecular biology of fruit ripening and maturation. (5)
4. Role of salicylic acid and strigolactones in plants. (5)
5. Molecular mechanism of flowering, gene expression during flower development, floral induction and control of flowering. (5)
6. Structures and function of plant photoreceptors. (5)
7. Genomics in plants stress tolerance: concept, Bioinformatics tools to validate the data from genomics, Development of molecular marker for physiological traits. (10)
8. Principle and applications of tracer techniques in biology. (6)
9. Molecular analysis of photosystem- II structure and function. (6)
10. Photorespiration and $C_4$ photosynthesis. (6)
11. RUBISCO: structure and function. (6)
12. Seed germination and vigor in plants, Fundamental of Plant growth and differentiation. (6)

**Practical Course**

**BOEP4.5**

**(Based on BOET4.9 & BOET4.10 - Plant Physiology, Plant Biochemistry & Plant Molecular Biology )**

**Points: 100** **12 hours/ week**

1. Quantitative estimation of nitrogen by Kjeldahl's method.
2. Determination of proline from plant tissues.
3. Determination of ascorbic acid oxidase activity in plant tissue.
4. Paper and thin layer chromatography of amino acids and sugars.
5. Quantitative estimation of total soluble sugar by Anthrone method.
6. Estimation of phosphorus content by Fiske- Subbarow' method.
7. Estimation of ascorbic acid in a plant tissue.
8. Separation of plant pigments by column chromatography.

9. Bioassay of auxin, gibberellins and cytokinins.
10. Quantitative estimation of amino acids and proteins by colorimetric method.
11. Isolation and estimation of DNA by diphenylamine reaction.
12. Isolation and estimation of RNA by weevil reaction.
13. Evaluation of $T_m$ of DNA.
14. Gel electrophoretic study of plant protein.
15. Isolation of plasmid and genomic DNA.

**Note: Regularly checked laboratory records, should be submitted at the time of term-end examination.**

***** ***** *****

| Course | Subject | Points | Credits | Hrs./Wk. |
|---|---|---|---|---|
| **BOET4.11** | Pteridology & Palaeobotany (Course - I) | **100** | **4** | **6** |
| **BOET4.12** | Pteridology & Palaeobotany (Course - II) | **100** | **4** | **6** |
| **BOEP4.6** | Practical based on BOET4.11 & BOET4.12 | **100** | **4** | **12** |
| **BOEPW4.1** | Project/ Review | **50** | **2** | **4** |
| **TOTAL (BOET4.11 + BOET4.12 + BOEP4.6 + BOEPW4.1)** | | **350** | **14** | **28** |

**EVALUATION SCHEME:**
**THEORY (BOET4.11):** Internal Assessment (20 points) + Term End Examination (80 points)
**THEORY (BOET4.12):** Internal Assessment (20 points) + Term End Examination (80 points)
**PRACTICAL:** Internal Assessment (20) + Term End Examination (80)

## Theoretical course
## BOET4.11

### Pteridology & Palaeobotany (Course – I)

**TEE points: 80** **Classes/ Semester: 80**

1. Essentials of geology in relation to palaeobotany: Earth's interior and crust; types of rocks and their interrelationships, fossiliferous rocks; tectonic forces-– stress, strain; geological structures-strike and dip, fold, joint, and fault. (10)
2. Continental drift, plate tectonics and plant fossils: Continental drift, plate tectonics and break up history of major continents; plant fossil evidences for the long journey of the continents; effects of continents and supercontinents on organic evolution and climate. (4)
3. Elements of stratigraphy and time scale: Definition, types, general principles of stratigraphy; code of stratigraphic nomenclature; correlation; concept and principle of geological time; major fossil groups used in time scale, types of facies and implication (5)
4. Precambrian life: Origin of life on earth and earliest record; Archean life, oxygenation of earth, Proterozoic life. (6)
5. Diversification and extinction of past vegetation: Rise of land vegetation; evolution of floras through ages, evolutionary theories, mass extinction and plant fossil records. (5)
6. Palaeofloristics and palaeogeography: Palaeofloristics zonations and palaeogeography in Palaeozoic (late Carboniferous to early Permian), Mesozoic (late Cretaceous) and Cenozoic (Eocene, and Miocene) time (15)
7. Nature's Green Revolution: Evolutionary rise of plants using C4 and CAM photosynthetic pathways, the first grasses. (3)

8. Plant-animal interactions in geologic past and their co-evolution: Early terrestrial ecosystem association, herbivory, fossil evidences, interaction with vertebrates, plants as habitat, other plant-animal interactions. (3)
9. Microfossils, nannofossils and palaeoecology : Morphology, geological occurrence and palaeoecological significance of blue green algae, bacteria, dinoflagellates, acritarchs, silicoflagellates, diatoms, coccolithophores, green algae, red algae, spores and pollen grains, radiolaria, forminifera, ostracodes, chitinozoa, conodont and nannofossils. (8)
10. Plant fossils as palaeoenvironmental proxies & climate change event: Analysis of palaeoenvironment by using plant fossils through different methods - leaf physiognomy, NLR of coexistence model, CLAMP, stomatal density and index, tree ring analysis; role of plant fossils in predicting future climate change. (4)
11. Life as Fuel Maker: sources of natural fuels-coal and oil; coalification process, coal and its varieties, constitution of coal, coal seams and coal fields; origin of petroleum, kerogen, migration and accumulation of petroleum and natural gas; coal and petroliferous basins in India; role of microfossils in fossil fuels exploration (3)
12. Indian fossil flora and palaeoenvironmental consideration: Indian mega and micro fossil records in reflecting palaeoenvironmental conditions with special reference to Gondwana, Deccan-Intertrappean, Siwalik, and Quaternary flora (10)
13. Recent perspectives in palaeobotanical research: Exploitation of ancient DNA in evolutionary research, techniques and limitations; uses of other fossil plant biomolecules, chemical constituents and stable carbon isotopes in palaeobotanical research. (4)

**Theoretical course**
**BOET4.12**

**Pteridology & Palaeobotany (Course – II)**

**TEE points: 80** **Classes/ Semester: 80**

1. Introduction: Concept of Pteridophyta as a single taxonomic unit and its origin. (4)
2. Taxonomic Treatments: Characters of some major groups of fern-families and fern-allies; phylogenetic position of Psilotales; recent taxonomic treatments of extant Lycopodiaceae and Ophioglossaceae; systematics and phylogeny of the Filicales; trends of evolutionary specialization in early land vascular plants. (6)
3. Ecology and Distribution: Ecological diversity of pteridophytes; Brief account of Palaeozoic and Mesozoic Lycopsids, Sphenopsids and Filicopsids in India; modern pteridophytic flora of India with special reference to endangered taxa and their conservation. (10)
4. Contribution of the ferns to an understanding of the life cycles of vascular plants: Sporogenesis and apospory in homosporous archegoniates, apogamy, apospory and apomixes, agamospory; relationship between heterospory and anisospory, sexuality in gametophytic growth, apogamous cycle, free sporing heterospory, the determination of femaleness in free sporing heterosporous plants. (9)
5. Comparative Anatomy: Stem, Root, and Leaf; types of stomata and their ontogenetic interrelationships; variation in the vasculature of petiole and the rachis and their probable lines of evolution. (10)

6. Cytogenetics & Genetics: Chromosome number and morphology, polyploidy and its origin in ferns; geographical distribution of polyploids; hybridization, evolutionary process in extant ferns; karyology in Psilotaceae, Isoetaceae, Lycopodiaceae, Selaginellaceae, Equisetaceae and selected ferns; breeding behavior in ferns. (10)
7. Spores: Structure, ontogeny and developmental trends in spores of extant pteridophytes; basic spore characters of extant pteridophytes (Psilotaceae, Lycopodiaceae, Selaginellaceae, Isoetaceae, Equisetaceae, Ophioglossaceae, Marattiaceae, Osmundaceae, Cyatheaceae, Pteridaceae, Parkeriaceae, Dennstaedtiaceae, Hymenophyllaceae, Thelypteridaceae, Polypodiaceae, Masileaceae, Salviniaceae); type species of selected spore genera of extinct pteridophytes; function of spores- predation, metabolism, germination. (12)
8. Gemetophyte: Effect of environment (light, temperature and different chemicals) on spore germination and early development of gametophytes; ontogeny of fern gametophytes, ultrastructure of fern gametophytic cells-protonemal cells and rhizoids, evolutionary trends in gametophyte morphology; a brief account of ultrastructural features, of male and female gametogenesis in ferns; fertilization and fertility. (15)
9. Chemosystematic overview: Analysis of the distribution of flavonoids, terpenoids, additional compound classes. (6)
10. Experimental aspects in respect to ecology: Ecology and geographic range, spore production, dispersal and viability, tolerance of desiccating conditions, deposition & establishment, prothallial development, ecological aspects of sexual maturity; various types of biotic interaction. (10)

**Practical Course**

**BOEP4.6**

**(Based on BOET4.11 & BOET4.12 - Pteridology & Palaeobotany )**

**Points: 100** **12 hours/ week**

1. Geological and geographical mapping of different sedimentary basins, coal and petroliferous basins in India.
2. Study of different rock types, fold, fault, BIF, verve sediments.
3. Demonstration on the preparation of anatomical slides of fossil materials by peel techniques.
4. Study of Precambrian microbiota, stromatolite.
5. Study of external and internal morphology of fossil pteridophytes, gymnosperms and angiosperms (available specimens) through geological ages.
6. Extraction of palynofossils from coal, lignite, peat using suitable techniques and interpretation of data for reconstruction of palaeovegetation and depositional environment.
7. Study of fossil dinoflagellates and other microfossils.
8. Study of extant pteridophytic spores (at least 10 different types) by acetolysis method.
9. Comparative study of vegetative organs of pteridophytes.
10. Comparative study of reproductive structures of pteridophytes.
11. Demonstration on fern gametophytic culture under laboratory conditions.
12. Visit to Palaeobotany Gallery of Indian Museum/ University Laboratory.
13. Field tour for study and collection of fossil materials / extant pteridophytes

**Note: Regularly checked laboratory records, permanent slides prepared during practical classes, preserved and dried specimens collected during field works should be submitted at the time of term-end examination.**

***** ***** *****

| Course | Subject | Points | Credits | Hrs./Wk. |
|---|---|---|---|---|
| **BOET4.13** | Taxonomy of Angiosperms & Biosystematics (Course - I) | **100** | **4** | **6** |
| **BOET4.14** | Taxonomy of Angiosperms & Biosystematics (Course - II) | **100** | **4** | **6** |
| **BOEP4.7** | Practical based on BOET4.13 & BOET4.14 | **100** | **4** | **12** |
| **BOEPW4.1** | Project/ Review | **50** | **2** | **4** |
| **TOTAL (BOET4.13 + BOET4.14 + BOEP4.7 + BOEPW4.1)** | | **350** | **14** | **28** |

**EVALUATION SCHEME:** **THEORY (BOET4.13):** **Internal Assessment (20 points) + Term End Examination (80 points)**
**THEORY (BOET4.14):** **Internal Assessment (20 points) + Term End Examination (80 points)**
**PRACTICAL:** **Internal Assessment (20) + Term End Examination (80)**

## Theoretical course
## BOET4.13

### Taxonomy of Angiosperms & Biosystematics (Course – I)

**TEE points: 80** **Classes/ Semester: 80**

1. History of taxonomic study in India including the contributions by W. Roxbugh, N. Wallich, J. D. Hooker, G. King, T. Cooke, J. S. Gamble, D. Prain, J. F. Duthie, K. P. Biswas, H. Santapau, and S. K. Mukherjee. (9)
2. A general survey of the following taxa of angiosperms (*sensu* APG III, 2009) with special reference to their characteristics, interrelationships, evolutionary trends: Piperales, Nymphaeales, Caryophyllales, Asterales, Liliales and Orchidales. (15)
3. General account of parasitic and carnivores plants. (5)
4. ICBN: Application of code with problems; nomenclature of cultivated and hybrid plants. Rules concerning to describe a new taxon. (5)
5. Origin of angiosperms: Theories, evidences, place and time of origin. (4)
6. Floristic regions of the world (after Takhtajan 1997): Idea about different Kingdoms and Sub kingdoms. Floristic features of the following regions: Eastern Asiatic region; Madagascar region; Indo - Malaysian sub - kingdom, Polynesian sub-kingdom, Neo - Caledonian sub - kingdom, Cape Kingdom. (6)
7. General account of cosmopolitan families, tropical families, temperate families and discontinuous families. (4)
8. Migration and dispersal of plants. (4)
9. Diversity of Flora in India: Composition, floristic divisions (after Balakrishnan, 1996) and the characteristics flora of Eastern Himalaya, Western Himalaya and Sunderbans. (6)
10. Endemism in India; invasion and introduction of plants in Indian flora. (6)
11. Botanical Survey of India: Activities and structural organization including different circles. (4)

12.Taxonomic literatures: Familiarizations with classical literatures, general index, monographs and revisions, floras and manuals, glossaries and dictionaries, icons, abstract, bibliography and review. Important periodicals of India and abroad. (4)

**Theoretical course**
**BOET4.14**

**Taxonomy of Angiosperms & Biosystematics (Course – II)**

**TEE points: 80** **Classes/ Semester: 80**

1. Biosystematics: Definition, aims, steps, categories, methods, limitations and scope. (5)
2. Variation and Speciation: Types of variation, variance analysis, isolating mechanisms and speciation. A preliminary idea about taxonomic and biological species concept and their advantages. (6)
3. Data sources of taxonomy: Anatomy, palynology, cytology, chemotaxonomy, serology, ultrastructure, SEM, TEM and molecular biology. (15)
4. Biodiversity: Concept, importance, conservation in relation to Indian perspective. Mega diversity, Hotspots. (6)
5. Conservation of plants: Causes of threat, lUCN - categories of rare, vulnerable, endangered and threatened plants; procedure of conservation - *in-situ* conservation: Biosphere Reserve, Wild life Sanctuaries, National Parks , World Heritage Cites; activities of Protected Area Networks; *ex-situ* conservation - principles, methods, definition, aims and activities of W.W.F., Red Data Book, MAB, CITES, Genetic resources centre: international networks, national institutions, genetic stock collection. DNA bank as Germplasm Collection. (14)
6. Cladistic approaches of classification: Definition; methodology of cladistics; merits and demerits of cladistics. (5)
7. Remote Sensing: Definition, basic principles, GIS (Geographical Information System) and GPS, applications in Botany. (5)
8. Ethnobotany: Definition, purpose, current trends, as a multidisciplinary science. (6)
9. Bio-piracy of medicinal plants of India and recommendations for promotion of traditional medicine and ethnobiology in India. Concept of ITK (Indigenous Technological Knowledge), IPR (Intellectual Property Right) and Patenting. (8)
10. Scope of medicinal plants for the welfare of rural people in West Bengal. (2)

**Practical Course**

**BOEP4.7**

**(Based on BOET4.13 & BOET4.14 - Taxonomy of Angiosperms & Biosystematics)**

**Points: 100** **12 hours/ week**

1. Drawing and description and identification of plant specimens (fresh and dry) from selected groups or families.
2. Identification of unknown plants with the help of keys from local, regional, continental floras and manuals.
3. Preparation of artificial indented/bracketed keys at family, generic and species level, based on locally available plants.

4. Preparation of floral diagrams of some species of selected families: Acanthaceae, Scrophulariaceae, Verbenaceae, Solanaceae, Amaranthaceae, Ephorbiaceae, Bignoniaceae, Pedaliaceae, Moringaceae, Gramineae, Cyperaceae, Violaceae, Polygalaceae, Aizoaceae, Molluginaceae and Rubiaceae.
5. Solving of nomenclatural problems based on the rules of ICBN.
6. Preparation of check list of the species of a genus following the Website of www.**ipni**.org/**ipni**/query_**ipni**.html; www.**ipni**.org*;* http://www.britannica.com/EBchecked/ topic/285218/Index-Kewensis*;* and the recently published local floras and periodicals.
7. Familiarity with taxonomic literatures: Dictionaries, Glossaries, Manuals, Floras, Bibliographies.
8. Study of pollen grains sculpture and aperture by revised or modified acetolysis method.
9. At least two field trips within and around the campus; compilation of field notes and preparation of herbarium sheets of the plants at least 30 abundant wild or cultivated plants.

**Note: Regularly checked laboratory records, permanent slides prepared during practical classes, preserved and dried specimens collected during field works should be submitted at the time of term-end examination.**

***** ***** *****

**SOFT CORE THEORY COURSES** (Any **one** to be chosen from following Courses)

| | |
|---|---|
| **BOSCT4.1 Evolution** | **BOSCT4.4 Mycorrhiza and Lichen** |
| **BOSCT4.2 Immunology** | **BOSCT4.5 Advanced Pteridology** |
| **BOSCT4.3 Intellectual Property Rights** | |

***** ***** *****

| Course | Course Name | Points | Credits | Hrs./Wk. |
|---|---|---|---|---|
| **BOSCT4.1** | **Evolution** | **50** | **2** | **2** |
| **EVALUATION SCHEME - THEORY:** | **Internal Assessment (10) + Term End Examination (40)** **TEE: 40 points** | | | |

**Theoretical course**
**BOSCT4.1**
**Evolution**

**TEE points: 40** **Classes/ Semester: 40**

1. Emergence of evolutionary thoughts: Lamarck; Darwin – concepts of variation, Neo-Darwinism, adaptation, struggle, fitness and natural selection. (8)
2. Origin of cells and unicellular evolution: Origin of basic biological molecules; abiotic synthesis of organic monomers and polymers; concept of Oparin and Haldane; experiment of Urey-Miller (1953); the first cell; evolution of prokaryotes; origin of eukaryotic cells; evolution of unicellular eukaryotes; anaerobic metabolism, photosynthesis and aerobic metabolism. (12)
3. Evolutionary timescale & diversification of plant life: The evolutionary time scale; eras, periods and epoch; major events in the evolutionary time scale; origins of unicellular and multicellular organisms; major groups of plants. (10)

4. Genetic variations: Origin of genetic variation; Mendelian genetics; polygenic traits, linkage and recombination; epistasis, gene - environment interaction; heritability; population genetics; molecular evolution; molecular clocks. (10)

***** ***** *****

| Course | Course Name | Points | Credits | Hrs./Wk. |
|---|---|---|---|---|
| **BOSCT4.2** | **Immunology** | **50** | **2** | **2** |
| **EVALUATION SCHEME - THEORY:** | **Internal Assessment (10) + Term End Examination (40)**<br>**TEE: 40 points** | | | |

**Theoretical course**
**BOSCT4.2**
**Immunology**

**TEE points: 40** **Classes/ Semester: 40**

1. Introduction: overview of the immune system. (1)
2. Cells and organs of Immune system: Hematopoietic stem cells, stromal cells, hematopoietic growth factors, lymphoid organs (primary and secondary) and cells, mononuclear cells, granulocytic cells, mast cells, dendritic cells- characteristics and functions. (8)
3. Types of Immunity: (i) Innate immunity and Adaptive immunity, Major Histocompatibility Complex (MHC) and their role in antigen presentation, cytokine. (5)
4. Antigens: Chemical nature, antigenicity, immunogenicity, hapten, epitopes, mitogens (definition, properties, examples); adjuvant (definition, examples, function). (4)
5. Immunoglobulins: Types, monoclonal and polyclonal antibody (definition and characteristics). (4)
6. Complement: Components, function, mode of action. (2)
7. Antigen - Antibody interactions: Agglutination, precipitation, immunodiffusion, immuno-electrophoresis. (4)
8. Hypersensitivity: Definition, types, examples. (2)
9. Vaccines: Active and passive immunization (definition, characteristics, examples and functions). Attenuated and inactivated viral or bacterial vaccines (definition, characteristic, functions, examples). (5)
10. Diagnostic immunology: ELISA, RIA, Immunofluorescence, Flow cytometry, Fluorescence activated cell sorting (FACS). (5)

***** ***** *****

| Course | Course Name | Points | Credits | Hrs./Wk. |
|---|---|---|---|---|
| **BOSCT4.3** | **Intellectual Property Rights** | **50** | **2** | **2** |
| **EVALUATION SCHEME - THEORY:** | **Internal Assessment (10) + Term End Examination (40)**<br>**TEE: 40 points** | | | |

**Theoretical course**
**BOSCT4.3**
**Intellectual Property Rights**

**TEE points: 40** **Classes/ Semester: 40**

1. Introduction: Meaning and forms of Intellectual Property Rights; International Conventions; World Intellectual Property Organisation; Indian scenario. (4)
2. Copyright: Background; Content and substance; Period and assignment of copyright; Infringement and remedies; penalties. (4)
3. Patents: Historical overview of Patent Law; purpose, policy and meaning of patent; objectives of Patent Law; patentability; procedure; rights and obligations of patent holder; infringement and remedies; penalties. (8)
4. Geographical Indications: Meaning and content; protection; procedure; period of validity; rights and obligations of registration owners; infringement and remedies; penalties. (6)
5. Protection of Plant Varieties & Farmers' Rights: Meaning and content; definitions; procedure; rights and privileges; compensations; compulsory licence; period of validity; revocation and cancellation of registration; infringement and remedies; penalties; National Gene Fund. (5)
6. Traditional Knowledge: Documentation of TK; IPR issues in protection of TK; value addition; transfer of TK. (4)
7. Biodiversity & Environment: Documentation; IPR issues in biodiversity conservation; Access to plant genetic resources and benefit sharing; Bioprospecting; Biopiracy; Implications in environmental policies; IPR in environmental sustainability. (6)
8. IP issues in Biotechnology: Patentability issues; Trade Secrets; IP management; Relevant International Treaties. (3)

***** ***** *****

| Course | Course Name | Points | Credits | Hrs./Wk. |
|---|---|---|---|---|
| **BOSCT4.4** | **Mycorrhiza and Lichen** | **50** | **2** | **2** |
| **EVALUATION SCHEME - THEORY:** | **Internal Assessment (10) + Term End Examination (40)**<br>**TEE: 40 points** | | | |

**Theoretical course**
**BOSCT4.4**
**Mycorrhiza and Lichen**

**TEE points: 40** **Classes/ Semester: 40**

1. Mycorrhizae: types, classification of Brundrett, 2004 (4)
2. Factors affecting mycorrhizal association (3)
3. Nature of interaction, specific recognition in mycorrhizal association (5)
4. Application in agriculture & forestry with special emphasis on as biofertilizer & bio-protector (9)
5. Lichens: types, growth forms, thallus morphology & anatomy (3)
6. Nature of symbiosis, nutrient exchange, water relation (4)
7. Ecological significance of lichens, sensitivity to air pollution (5)
8. Lichen and its products: economic uses & application (7)

***** ***** *****

| Course | Course Name | Points | Credits | Hrs./Wk. |
|---|---|---|---|---|
| **BOSCT4.5** | **Advanced Pteridology** | **50** | **2** | **2** |
| **EVALUATION SCHEME - THEORY:** | **Internal Assessment (10) + Term End Examination (40)**<br>**TEE: 40 points** | | | |

**Theoretical course**
**BOSCT4.5**
**Advanced Pteridology**

**TEE points: 40** **Classes/ Semester: 40**

1. Recent approaches of fern classification: a brief outline of classification and characteristics up to family level, phylogeny and evolutionary relationships among major lineages. (5)
2. Structure and evolution of fern plastid genome: fern chloroplast genomics, PCR mapping of fern plastid genome, future prospects. (5)
3. Evolution of the nuclear genome of ferns and Lycophytes: a brief account of previous works, current perspectives and future goal. (5)
4. The sporophytes of seed free vascular plants-major vegetative developmental features and molecular genetic pathways: Sporophyte body plans, embryogeny, apical meristem structure, branching; Leaf development, developmental genes, micro RNA regulations of genes. (6)
5. Ecotoxicology and bioremediation in ferns: ferns and ecotoxicology, chronic phytotoxicity in gametophytes, Arsenic hyperaccumulator fern *Pteris vittata*, utilities of brake fern for phytoremediation. (10)
6. Therapeutic applications: Fern as Folk-medicine, pharmaceutical development and chemical identification of active principles, fern as natural antioxidant, natural antimicrobial agents and air purifier. (9)

***** ***** *****