University of Kalyani

M.Sc. Botany
Choice Based Credit System

Syllabus

(2021 – 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 Core (COR) Courses, Ability Enhancement Compulsory Courses (AECC), Skill Enhancement Courses (SEC), Generic Elective Courses (GEC) and Discipline Specific Elective (DSE) courses. All core (COR) and Special paper DSE Courses have both theoretical and practical courses. COR, AECC, SEC and GEC courses are compulsory. DSE courses should be opted by the students and allotted to them as per availability of the faculty. GEC course should be offered to the students of other departments and M.Sc. Botany students should opt one GEC course from the P.G. subjects other than Botany. There shall be a Project /Dissertation in the DSE 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 semesters: July to December; II and IV semesters: January to June, or as specified in the Academic Calendar of the University of Kalyani.

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 at the time of advertisement.
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 84 credits in a minimum of two years.

ATTENDANCE

8. A student is required to attend all classes. Theoretical 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 (TEE) and (b) Internal Assessment (IA). 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 points (marks) in each Course 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
COR	60	15	75	20	5	25
AECC, SEC	20	5	25	-	-	-
GEC, DSE (soft core)	40	10	50			
DSE (special paper)	80	20	100	80	20	100
Project/**Dissertation**				80	20	100

13. Duration of examination of theoretical courses up to 25 points shall be one hour, 50 points two hours, 60 points two and half hours, 75 points three hours and 100 points

four hours. The same for the practical courses up to 25 points shall be two hours and up to 100 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**, two class tests each for 12 points (for COR courses) or 8 points (for GEC and DSE soft core courses) or 15 points (for DSE special paper courses) will be conducted comprising of objective (1 mark) and short (3-5 marks) type questions for each Course. The Class test will be for a duration of 45 minutes (for 12 points), or 30 minutes (for 8 points), or 60 minutes (for 15 points). The average of marks obtained in two class tests will be considered. The mode of internal assessment of AECC and SEC courses will be informed later by the concerned teachers. Points will also be awarded for class attendance and/or assignments for each course during each semester (3 points for COR courses, 2 points for DSE soft core courses and 5 points for GEC and DSE major courses). For scoring of attendance, the following principle will be followed: for ≥80% attendance 100% point i.e., 3/2/5; 79-70% attendance 75% point i.e., 2/1/4; 69-60% attendance 60% point i.e., 1/1/3.

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 as per University P.G. regulation. 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 Syllabus of the Choice Based Credit System

Course Categories: **COR:** Core; **AECC:** Ability Enhancement Compulsory Courses, **SEC:** Skill Enhancement Courses, **GEC:** Generic Elective Courses, **DSE:** Discipline Specific Elective

Course Transaction Categories: **T:** Theory; **P:** Practical**; PW:** Project Work

Evaluation Categories: **IA:** Internal Assessment; **TEE:** Term End Examination

Course No.	Course Name	Point	Credit	Hrs/ week	Page no. for detail
SEMESTER I					
CORE COURSE THEORY					
BOTCOR T101	Microbiology & Immunology	75	3	4	9-10
BOTCOR T102	Phycology & Mycology	75	3	4	11-13
BOTCOR T103	Bryology & Pteridology	75	3	4	14-15
BOTCOR T104	Taxonomy of Angiosperms & Biosystematics, Gymnosperms & Plant Anatomy	75	3	4	16-17
BOTAECC	Environmental Biology	25	2	2	19
CORE COURSE PRACTICAL					
BOTCOR P101	Practical based on Microbiology & Immunology	25	1	3	10
BOTCOR P102	Practical based on Phycology & Mycology	25	1	3	13-14
BOTCOR P103	Practical based on Bryology & Pteridology	25	1	3	15
BOTCOR P104	Practical based on Taxonomy of Angiosperms & Biosystematics, Gymnosperms & Plant Anatomy	25	1	3	17-18
Total Points & Credits in Semester I		**425**	**18**	**30**	
SEMESTER II					
CORE & GENERIC ELECTIVE COURSES THEORY					
BOTCOR T205	Palaeobotany & Palynology	75	3	4	20-21
BOTCOR T206	Plant Physiology & Biochemistry	75	3	4	22-24
BOTCOR T207	Genetics, Cytogenetics, Plant Breeding & Biometry	75	3	4	25-26
BOTGEC T	Plants in Human Welfare	50	4	4	27-29
CORE COURSE PRACTICAL					
BOTCOR P205	Practical based on Palaeobotany & Palynology	25	1	3	22
BOTCOR P206	Practical based on Plant Physiology & Biochemistry	25	1	3	24-25
BOTCOR P207	Practical based on Genetics, Cytogenetics, Plant Breeding & Biometry	25	1	3	26-27
LIBRARY/ FIELD WORK/ TUTORIAL/ REMEDIAL CLASSES / EXTRA-CURRICULAR ACTIVITIES				5	
Total Points & Credits in Semester II		**350**	**16**	**30**	

Course No.	Course Name	Point	Credit	Hrs/ week	Page no. for detail
SEMESTER III					
CORE COURSE THEORY					
BOTCOR T309	Plant Pathology & Crop Protection	75	3	4	30-31
BOTCOR T310	Plant Molecular Biology & Biotechnology	75	3	4	32-33
BOTCOR T311	Plant Ecology, Biodiversity & Conservation	75	3	4	34-36
CORE COURSE PRACTICAL					
BOTCOR P309	Practical based on Plant Pathology & Crop Protection	25	1	3	31
BOTCOR P310	Practical based on Plant Molecular Biology & Biotechnology	25	1	3	33-34
BOTCOR P311	Practical based on Plant Ecology, Biodiversity & Conservation	25	1	3	36-37
DSE (SOFT CORE) THEORY: Any **one** from the following;					
BOTDSE T301.1	Forensic Botany	50	2	2	37-38
BOTDSE T301.2	Fundamentals of Crop Physiology	50	2	2	38-40
BOTDSE T301.3	Industrial Microbiology	50	2	2	40
BOTDSE T301.4	Pharmacognosy	50	2	2	40-42
SKILL ENHANCEMENT COURSE THEORY					
BOTSEC T	Intellectual Property Rights	50	2	2	42-43
BOTDSE PW (Project/Dissertation/Review Work) **Discipline Specific Elective (DSE) special paper Courses are allotted & BOTDSE PW course is initiated in Semester III**				5	
Total Core Points/ Credits in Semester III		**300**	**12**	**21**	
Total DSE (Soft Core) Points/ Credits in Semester III		**50**	**2**	**2**	
Total SEC Points/ Credits in Semester III		**50**	**2**	**2**	
Total Points/ Credits in Semester III		**400**	**16**	**30**	
SEMESTER IV					
DISCIPLINE SPECIFIC ELECTIVE THEORY Any **one** single combination of Course – I & Course – II from the following**:**					
BOTDSE T402.1	Microbiology (Course – I)	100	8	8	44-45
BOTDSE T403.1	Microbiology (Course – II)	100	8	8	45-46
BOTDSE T402.2	Molecular Genetics, Advanced Cell Biology, Molecular Breeding & Plant Tissue Culture (Course – I)	100	8	8	47-48
BOTDSE T403.2	Molecular Genetics, Advanced Cell Biology, Molecular Breeding & Plant Tissue Culture (Course – II)	100	8	8	48-50
BOTDSE T402.3	Mycology & Plant Pathology (Course – I)	100	8	8	51-52

BOTDSE T403.3	Mycology & Plant Pathology (Course – II)	100	8	8	52-53
BOTDSE T402.4	Palaeobotany, Palynology & Evolution (Course – I)	100	8	8	55-56
BOTDSE T403.4	Palaeobotany, Palynology & Evolution (Course – II)	100	8	8	56-57
BOTDSE T402.5	Phycology (Course – I)	100	8	8	59-60
BOTDSE T403.5	Phycology (Course – II)	100	8	8	60-61
BOTDSE T402.6	Plant Physiology, Biochemistry & Plant Molecular Biology (Course – I)	100	8	8	62-63
BOTDSE T403.6	Plant Physiology, Biochemistry & Plant Molecular Biology (Course – II)	100	8	8	63-64
BOTDSE T402.7	Pteridology (Course – I)	100	8	8	65-67
BOTDSE T403.7	Pteridology (Course – II)	100	8	8	67
DISCIPLINE SPECIFIC ELECTIVE PRACTICAL					
BOTDSE P404.1	Practical based on Microbiology (Course I & II)	100	8	6	46-47
BOTDSE P404.2	Practical based on Molecular Genetics, Advanced Cell Biology, Molecular Breeding & Plant Tissue Culture (Course – I & II)	100	8	6	50-51
BOTDSE P404.3	Practical based on Mycology & Plant Pathology (Course – I & II)	100	8	6	54-55
BOTDSE P404.4	Practical based on Palaeobotany, Palynology & Evolution (Course – I & II)	100	8	6	57-58
BOTDSE P404.5	Practical based on Phycology (Course – I & II)	100	8	6	61-62
BOTDSE P404.6	Practical based on Plant Physiology, Biochemistry & Plant Molecular Biology (Course – I & II)	100	8	6	64-65
BOTDSE P404.7	Practical based on Pteridology (Course – I & II)	100	8	6	67-68
DISCIPLINE SPECIFIC ELECTIVE COURSE PROJECT /REVIEW WORK					
BOTDSE PW	Project / Dissertation/ Review Work	100	8	6	
DSE (SOFT CORE) THEORY: Any **<u>one</u>** from the following;					
BOTDSE T405.1	Advanced Immunology	50	2	2	68-69
BOTDSE T405.2	Advanced Pteridology	50	2	2	69-70
BOTDSE T405.3	Mushroom Biology	50	2	2	70-71
Total DSE (Special paper) Course Points/Credits in Semester IV		**400**	**32**	**28**	
Total DSE (Soft Core) Points/ Credits in Semester IV		**50**	**2**	**2**	
Total Points & Credits in Semester IV		**450**	**34**	**30**	
TOTAL POINTS & CREDITS : **425 (18) + 350 (16) + 400 (16) + 450 (34)**		**1625**	**84**		

SEMESTER IV

Course No.	Course Name	Points	Credits	Hrs./Wk.
BOTDSE T402.1	**Microbiology (Course – I)**	**100**	**8**	**8**
BOTDSE T403.1	**Microbiology (Course – II)**	**100**	**8**	**8**
BOTDSE P404.1	**Practical based on Microbiology (Course – I & II)**	**100**	**8**	**6**
BOTDSE PW	**Project/ Review**	**100**	**8**	**6**
TOTAL (BOTDSE T402.1 + T403.1 + P404.1 + PW)		**400**	**32**	**28**

EVALUATION SCHEME-
THEORY (BOTDSE T402.1) **: Internal Assessment (20 points) + Term End Examination (80 points)**
THEORY (BOTDSE T403.1) **: Internal Assessment (20 points) + Term End Examination (80 points)**
PRACTICAL (BOTDSE P404.1)**: Internal Assessment (20 points) + Term End Examination (80 points)**
PROJECT/REVIEW : Internal Assessment (20 points) + Term End Examination (80 points)

Course Objectives:

Microbiology as special paper of M.Sc. Botany course serves to impart advanced training to the students in the field of Microbiology with focus on microbial diversity, bioprospecting and applications of microbes for obtaining various biologically significant metabolites and in bioremediation of polluted environments. Students undergo hands-on training with state-of-the art technologies and are trained so as to develop an aptitude for independent research. The Programme equips students for higher research leading to the Ph.D. Degree in India or in International Universities overseas, or for employment in Research Institutes, in teaching, and in Industry.

Learning Outcomes:

- To provide value-based education, with academic excellence and advanced research and to raise skilled candidates with research caliber in the field of Microbiology
- To inculcate the advanced concepts of Microbiology including taxonomy, physiology ¬ Immunology, biomolecular interactions, etc.
- To impart the scope for the application of concepts learned in the subject.
- To introduce about the recent advances in the field of Microbiology and its importance in research.

Theoretical Course

BOTDSE T402.1

MICROBIOLOGY (COURSE – I)

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

Course Content: **(No. of Classes allotted)**

1. **Origin and Diversity of Microorganisms:** (20)
   - Primitive life forms; evidence of microbial life on early earth; origin of life; earliest organisms and metabolic strategies.
   - Microbial phylogeny; universal tree of life.
   - Bacterial taxonomy; nomenclature and Bergey's manual; classification and species concept; nomenclature and formal taxonomic standing, conventional taxonomy, molecular taxonomy.
2. **Microbial Physiology and Metabolism:** (30)

- Enzymes- classification and nomenclature, general properties, extraction, assay and purification; mechanism of enzyme action, enzyme kinetics, enzyme inhibition.
- Carbohydrate metabolism- Embden-Meyerhoff-Parnas pathway, TCA cycle, Pentose phosphate pathway, Electron transport chain and phosphorylation.
- Anaerobic respiration- nitrate, sulfate, thiosulfate, elemental sulfur and carbon dioxide as electron acceptor.
- Fermentation- alcoholic, lactate, formate, acetate, propionate, butyrate, mixed acid and butane diol; EntnerDuodoroff pathway, Stickland reaction.
- Amino acid metabolism- Concept of Exo- and Endo- peptidases, transamination, deamination, transmethylation and decarboxylation; Biosynthesis of lysine, glutamic acid and phenylalanine; protein biosynthesis.
- Lipid metabolism- Detailed account of oxidation of saturated, unsaturated and odd-carbon fatty acids.
- Nucleic acid metabolism- concept of purine and pyrimidine metabolism.
- Oxygenic and anoxygenic photosynthesis , chemosynthesis.

3. **Environmental Microbiology:** (14)
   - Microbial interactions- plant-microbes, animal-microbes, microbe-microbe interactions, biofilm and its significance.
   - Microbiology of air, water and soil; deep sea ecosystem-barotolerant and barophilic bacteria.
   - Microorganisms in mineral recovery; microbial leaching of metals.
   - Biogeochemical cycling and microbes.
   - Microbes and ecological management.
   - Biomethanation from agricultural and food processing wastes.
4. **Agricultural Microbiology:** (8)
   - Exploitation of microbes for crop improvement and crop protection.
   - Biological control of plant diseases and agricultural antibiotics.
   - Biopesticides and biofertilizer.
5. **Industrial Microbiology:** (8)
   - Fermenters- stirred tank, bubble column, air lift, packed bed.
   - Industrial production of ethyl alcohol, acetic acid, penicillin, vitamin B12 and amylase.

Theoretical Course

BOTDSE T403.1

MICROBIOLOGY (COURSE – II)

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

Course Content: **(No. of Classes allotted)**

1. **Microbial Genetics:** (20)
   - Bacterial genome replication and cell cycle; Plasmid replication, prokaryotic transcription and translation.
   - Regulation of gene expression in prokaryotes.
   - Genetic recombination in bacteria.
   - Viral genome replication.

2. **Immunology:** (30)
   - Overview of the immune system.
   - Innate immunity and adaptive immunity, major histocompatibility complex (MHC) and their role in antigen presentation, cytokines.
   - Antigen- chemical nature, types; hapten, adjuvant.
   - Monoclonal and polyclonal antibodies.
   - Antigen-antibody reaction.
   - Hypersenitivity and allergy.
   - Vaccines and vaccination.
   - Immunological techniques- ELISA, RIA, Immunofluorescence, Immunoelectrophoresis, Flow cytometry, Fluorescence-Activated Cell Sorting (FACS).
3. **Medical Microbiology**: (15)
   - Principle of epidemiology.
   - Air borne diseases, water borne diseases, food borne diseases, arthropod borne diseases, sexually transmitted diseases, respiratory diseases.
4. **Mathematical approach for microbiologists:** (15)
   - Numerical Microbiology Problem solving,
   - Concept of mathematical models, Application of Mathematical models to microbiological processes.

Practical Course
BOTDSE P404.1
Practical based on MICROBIOLOGY (COURSE I & II)

Points: 100 **6 hours/ week**

1. Isolation and characterization of bacteria from different habitat. (1)
2. Growth study of bacteria in presence of inhibitor/stimulator in the medium. (1)
3. Determination of the potability of water (MPN method). (1)
4. Isolation of root nodule bacteria, their characterization and induction for root hair curling and artificial nodulation. (1)
5. Isolation of phosphate solubilizing, cellulose degrading, nitrogen fixing and IAA producing bacteria from soil. (2)
6. Determination of phenol coefficient of different common disinfectants. (1)
7. Microbial load and quality assessment of salad vegetables. (1)
8. Microbiological examination of milk by methylene-blue dye reduction test. (1)
9. Determination of MIC for different chemicals for inhibition of bacterial growth. (1)
10. Isolation and identification of *E. coli*, faecal *E. coli* and *Salmonella* from domestic water and scoring of antibiotic resistant cells present in the population. (1)
11. To determine the dilution end point of viruses. (1)
12. To determine the thermal inactivation point of viruses. (1)
13. Isolation of bacterial DNA and its quantification by chemical method. (1)
14. Induced mutagenesis and isolation of mutants; replica plating technique. (1)
15. Detection of soil protozoa having predatory role on soil bacteria. (1)
16. Blood grouping (ABO and Rh systems) and cross-matching. (1)
17. Agglutination tests (Widal test, RPR test. (2)
18. Immunoprecipitation (Ouchterlony technique). (1)

19. Visit to any industry/research institute and reporting the activity.

Suggested Readings:

1. Microbiology by M.J. Pelczar Jr., E.C.S. Chan and N.R. Krieg. TMH
2. General Microbiology by R.Y. Stanier, E.A. Adelberg, J.L. Ingram . MacMillan
3. Brock biology of microorganisms by M.T. Madigan, J.M. Martinko, J. Parker. PHI
4. Bacterial metabolism by G. Gottschalk. Springer
5. Microbial physiology by A.G. Moat, J.W. Foster. John Wiley
6. Industrial microbiology by L.E. Cassida
7. Medical microbiology by Greenwood

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Course No.	Course Name	Points	Credits	Hrs./Wk.
BOTDSE T402.2	**Molecular Genetics, Advanced Cell Biology, Molecular Breeding & Plant Tissue Culture (Course - I)**	**100**	**8**	**8**
BOTDSE T403.2	**Molecular Genetics, Advanced Cell Biology, Molecular Breeding & Plant Tissue Culture (Course - II)**	**100**	**8**	**8**
BOTDSE P404.2	**Practical based on Molecular Genetics, Advanced Cell Biology, Molecular Breeding & Plant Tissue Culture (Course – I & II)**	**100**	**8**	**6**
BOTDSE PW	**Project/ Review**	**100**	**8**	**6**
TOTAL (BOTDSE T402.2 + T403.2 + P404.2 + PW)		**400**	**32**	**28**

EVALUATION SCHEME-

THEORY (BOTDSE T402.2) **: Internal Assessment (20 points) + Term End Examination (80 points)**

THEORY (BOTDSE T403.2) **: Internal Assessment (20 points) + Term End Examination (80 points)**

PRACTICAL (BOTDSE P404.2)**: Internal Assessment (20 points) + Term End Examination (80 points)**

PROJECT/REVIEW : Internal Assessment (20 points) + Term End Examination (80 points)

Theoretical Course
BOTDSE T402.2
MOLECULAR GENETICS, ADVANCED CELL BIOLOGY, MOLECULAR BREEDING & PLANT TISSUE CULTURE (COURSE - I)

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

Course Objectives:

To make students understand the concepts of cell cycle regulation and deregulation, genetics behind the floral organ development, replication of chromosome termini, epigenetics, RNA biology, concept of genome, metagenomics, genome editing technologies, advances in the field of proteomics, intracellular compartments and protein sorting, and cell signaling.

Learning Outcomes:

- The unit will enable the students to understand the role of proteins in controlling cell cycle.
- The unit will provide an understanding of the basic concept of epigenetics and the underlying mechanisms.
- The unit will enable the students to understand the concept of proteome, protein separation and identification techniques, and post-translational modifications of proteins.
- Students will also gain knowledge about genome editing techniques, membrane transport, intracellular compartments and protein sorting and cell signaling.

Course Content: **(No. of Classes allotted)**

1. **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. (8)
2. **Genes Directing Flower Development in *Arabidopsis*:** ABC model, mutations; floral quartet model of floral organ specification. (2)
3. **Replication of Chromosome Termini:** End-replication problem and aging in human; Telomerase. (2)
4. **Epigenetics:** Introduction, methylation, histone modifications, epialleles. (3)
5. **RNA Biology:** Gene silencing through antisense RNA technology and Ribozymes; RNA interference (RNAi) by small regulatory RNAs: different types of small non-coding RNAs, their biogenesis and functions in posttranscriptional gene silencing; applications of RNAi in crop quality improvement. (10)
6. **Genomes and Genomics:** Concept of genome; Genome sequencing strategies, Genomes of Yeast, *Arabidopsis* and rice, Genome annotation, Genome duplication, Approaches to analyze differential gene expression- ESTs, Microarrays and their applications, Reverse genetics-Gene tagging, Gene trapping, Gene silencing and Gene knockout; Metagenomics. (10)
7. **Genome Editing Technologies:** CRISPR, TALEN, LEAPER and their applications in crop improvements. (10)
8. **Proteomics:** Concept of proteome; Functional, structural and differential proteomics; Principle of 2D gel electrophoresis (2-DE); advantages and limitations of 2-DE; Protein Fingerprinting; Gel free proteomics (iTRAQ); Mass spectrometry (MALDI-TOF MS);Post-translational modifications of proteins; Applications of proteomics in agriculture.(10)
9. **Membrane Transport:** Lipid bilayer, Membrane transport proteins, Active and passive membrane transport, Ion channels. (3)
10. **Intracellular Compartments and Protein Sorting:** Compartmentalization of Higher Cells, Signal peptides and signal patches; Transport of proteins into nucleus, mitochondria and chloroplasts; Transport of proteins from E.R. through the golgi apparatus; Role of M6P (Mannose 6-Phosphate) receptor in lysosomal enzyme sorting; Transport from the Plasma membrane via Endosomes- Endocytosis. (17)
11. **Cell Signaling:** Cell surface and intracellular receptors; Ion channel linked, Signaling via G-protein linked cell surface receptors. (5)

Theoretical Course
BOTDSE T403.2
MOLECULAR GENETICS, ADVANCED CELL BIOLOGY,
MOLECULAR BREEDING & PLANT TISSUE CULTURE (COURSE - II)

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

Course Objectives:

This course aims to teach the breeding methods, qualitative and quantitative traits, self-incompatibility and male sterility, heterosis, molecular markers, genetic map construction, mutation breeding, breeding for disease resistance, heritability, experimental designs, bioreactors, organogenesis and micropropagation.

Learning Outcomes:

On completion of the course the students will gain knowledge about:

- Principles of plant breeding, different types of breeding techniques used, breeding for disease resistance, heritability and experimental designs.
- The unit will enable the students to learn about molecular markers and construction of Genetic map.
- Principles and methods of plant tissue culture and micropropagation protocol.

Course Content: **(No. of Classes allotted)**

1. **Genetic Systems and Breeding Methods:** Selection and breeding strategies for self-pollinated, cross-pollinated and clonally propagated plants. (6)
2. **Continuous Variation and its Significance:** Qualitative traits and discrete variation, Quantitative trait and continuous variation, Polygenes and polygenic inheritance. (3)
3. **Self-Incompatibility:** Basic concept, Genetic and molecular basis of self-incompatibility, Methods to overcome self-incompatibility in plants. (4)
4. **Male Sterility:** Overview; Types of male sterility; Mechanisms, Maintenance of male sterile line, Transgenic male sterility, Induction of male sterility, utilization in crop improvement. (5)
5. **Heterosis:** Concept, Types of heterosis, genetic and molecular basis of heterosis and inbreeding, utilization in crop improvement. (4)
6. **Molecular Markers:** Development of molecular markers; trends and progress, RFLP, PCR based, single locus and multi-locus markers, NGS based markers; Applications in crop improvement. (8)
7. **Genetic Maps:** Construction of linkage maps, high-density maps, QTL mapping, association mapping, integration of genetic maps with physical maps/chromosomes. (4)
8. **Molecular Breeding:** Gene tagging, Marker Assisted Selection (MAS), Bulk Segregation Analysis (BSA), genomic selection, genome-wide association study (GWAS). (6)
9. **Mutation Breeding:** Utility and accomplishment of induced mutations. Management of M1 and M2generations, Factors influencing the mutation spectrum and the quality of mutants. (3)
10. **Breeding for Disease Resistance:** Pathogenicity vs. Virulence, Physiological races and differential hosts, Models for plant pathogen recognition, Flor's hypothesis, Vertical and Horizontal resistance. (3)
11. **Back Cross Method of Breeding**: Significance and limitations; multiline concept. (2)
12. **Heritability:** Understanding, Components of phenotypic variance, Broad-sense and narrow-sense heritability. (2)
13. **Design of Experiments:** general principles of field trails, randomized blocks, latin square, split plot designs, layout of breeding experiment. (3)
14. **Bioreactors:** Concept; Types of bioreactors- batch, continuous, multistage and immobilized call bioreactors; Application in plant tissue culture. (2)
15. **Organogenesis:** Developmental sequences, Mechanism of action of plant hormones, Control of *in vitro* organogenesis by cyclin-dependent kinase activity. (5)
16. **Somatic Embryogenesis:** Gene expression and signal transduction during embryogeneis-Role of *SERK* and *LEC* genes, Brassinosteroid (*BR*) signaling, Artificial seeds. (5)

17. **Somatic Hybridization:** Protoplast isolation technique, protoplast fusion, selection of hybrid cells- Homokaryons, Heterokaryons, Symmetric and asymmetric hybrids, fate of plasmagenes, Cybrids. (3)
18. ***In vitro* Genetic Variation:** Somaclonal and gametoclonal variation, Isolation and characterization of somaclones, Molecular basis of somaclonal variation, Advantages of somaclonal variation over induced mutations, Applications in crop improvement, *In vitro* mutagenesis and mutant selection. (6)
19. **Micropropagation**: Overview, Stages of micropropagation, Advantages and limitations, Horticultural Uses, Production of virus-free plants, Molecular and immunological techniques of plant virus detection**,** Genetic assessment by RAPD, RFLP, ISSR and SSR markers. (6)

Practical Course

BOTDSE P404.2

Practical based on MOLECULAR GENETICS, ADVANCED CELL BIOLOGY, MOLECULAR BREEDING & PLANT TISSUE CULTURE (COURSE I & II)

Points: 100 **6 hours/ week**

1. DNA extraction and estimation.
2. Visualization of plant genomic DNA by agarose gel electrophoresis.
3. Amplification of extracted DNA from plant material using polymerase chain reaction.
4. RNA extraction and estimation.
5. Formaldehyde gel electrophoresis of total RNA.
6. cDNA preparation and gene expression.
7. Extraction and estimation of protein from plant sample.
8. Protein separation by one-dimensional SDS-polyacrylamide gel electrophoresis (SDS-PAGE).
9. Isolation of plasmid DNA from *E. coli*
10. Restriction digestion of DNA and restriction mapping.
11. Pollen fertility and viability analysis.
12. Plant tissue culture media preparation.
13. Micropropagation through axillary bud culture.
14. Callus and cell suspension culture technique.
15. Seed culture technique.
16. Hardening of micropropagated plantlets.

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

Suggested Readings:

1. *i*Genetics- A Molecular Approach- Peter J. Russell (Pearson Int. Edition)
2. Concepts of Genetics- Klug W.S., Cummings M.R., Spencer C.A. and Palladino M.A. (Pearson Int. Edition).
3. Genes XII- Lewin Benjamin (Jones & Bartlett publishers)
4. Molecular Cell Biology- Lodish H, Berk A, Kaiser C.A., Krieger M., Scott M.P., Bretscher A., Ploegh H. &Matsudaira P. (W.H. Freeman & Co.)

5. Molecular Biology of the Cell, Alberts, Bruce; Johnson, Alexander; Lewis, Julian; Raff, Martin; Roberts, Keith; Walter, Peter New York and London: Garland Science.
6. Principles of Genetics- Snustad D.P. and Simmons M.J. (John Wiley & sons Inc.)
7. Principles of Genetics- Robert H. Tamarin (Tata McGraw-Hill)
8. An Introduction to Genetic Analysis- Anthony J.F. Griffiths, Susan R. Wessler, Sean B. Carroll, John Doebley (WH Freeman)
9. Bhojwani, S.S. and Razdan, M.K. 1996. Plant Tissue Culture: Theory and Practice (a revised edition). Elsevier Science Publishers, New York, USA.
10. Bojwani, S.S. 1990. Plant Tissue Culture: Applications and Limitations, Elsevier Science Publisher, New York, USA.
11. Collins, H.A. and Edwards, S. 1998. Plant Cell Culture, Bios Scientific Publishers, Oxford, UK.
12. George E.F., Hall M.A. and Klerk J.D. Plant Propagation by Tissue Culture (3rd Ed.), Springer
13. Khasim, S.M. 2002. Botanical Microtechnique: Principles and Practice, Capital Publishing Company, New Delhi.
14. Vasil, I.K. and Thorpe, T.A. 1994. Plant Cell and Tissue Culture, Kluwer Academic Press, The Netherlands.

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Course No.	Course Name	Points	Credits	Hrs./Wk.
BOTDSE T402.3	**Mycology & Plant Pathology (Course - I)**	**100**	**8**	**8**
BOTDSE T403.3	**Mycology & Plant Pathology (Course - II)**	**100**	**8**	**8**
BOTDSE P404.3	**Practical based on Mycology & Plant Pathology (Course – I & II)**	**100**	**8**	**6**
BOTDSE PW	**Project/ Review**	**100**	**8**	**6**
TOTAL (BOTDSE T402.3 + T403.3 + P404.3 + PW)		**400**	**32**	**28**

EVALUATION SCHEME-
THEORY (BOTDSE T402.3) **: Internal Assessment (20 points) + Term End Examination (80 points)**
THEORY (BOTDSE T403.3) **: Internal Assessment (20 points) + Term End Examination (80 points)**
PRACTICAL (BOTDSE P403.3)**: Internal Assessment (20 points) + Term End Examination (80 points)**
PROJECT/REVIEW : Internal Assessment (20 points) + Term End Examination (80 points)

Theoretical Course
BOTDSE T402.3
MYCOLOGY & PLANT PATHOLOGY (COURSE – I)

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

Course Objectives:

This course aims to teach the recent ideas regarding phylogenetic position of fungus & its sub-groups, their metabolic pathways, sexual & non-sexual variation and their detection, genomics, and cloning & expression of heterologous genes. Role of pheromones in mating, dimorphism, morphogenesis in slime molds, virulence factors responsible for mycoses, and protein synthesis regulation under stress will be taught with recent information. Activities of fungi as mycorrhiza, saprophytes, mycoremediating agents, and their industrial importance, long term preservation in culture repositories, mycological database & molecular identification will also be informed to the students.

Learning Outcomes:

- ❖ Students will understand modern trend in fungal classification, and learn about the pathways involved in biosynthesis of chitin, lysine and other secondary metabolites.
- ❖ Students will know about the variations & genome organization of fungi and learn about the cloning & expression of heterologous gene of industrial importance.
- ❖ Students will learn about hormonal control in mating, factors responsible for dimorphism & morphogenesis in slime molds and how pathogenic fungi infect a human being. Students will also know how the fungi survive under nutrient stress, thermal stress and metal stress.
- ❖ Students will get idea about the uses of mycorrhiza, and role of fungi in production of enzymes, antibiotics, organic acids & alcohol. Moreover, students will know how the fungi can degrade cellulose, lignin and other recalcitrant compounds and act as mycoremediating agents.
- ❖ They will understand how fungal cultures are preserved for longer period in culture repositories, and learn about mycological database and fungal barcoding.

Course Content: **(No. of Classes allotted)**

1. **Origin of Fungi and their Interrelationships**; phylogenetic system of classification. (4)
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** with special emphasis on plasmids and transposable elements; cloning and expression of heterologous genes in industrially important filamentous fungi; protoplast fusion technology. (12)
5. **Differentiation and Sex Hormones in Fungi;** morphogenesis in slime molds; mould-yeast dimorphism, mating and hormonal control. (10)
6. **Virulence Mechanisms of Human Pathogenic Fungi.** (4)
7. **Regulation of Protein Synthesis in Fungi**; heat shock protein and chaperon, development of thermo-tolerance by heat-shock and other stresses. (5)
8. **Mycorrhizae**: nature of interaction, application in agriculture & forestry with special emphasis on as biofertilizer & bio-protector. (6)
9. **Fungi as Saprotrophs;** decomposition and decay of wood; biodeterioration. (6)
10. **Mycoremediation**, metal tolerance, biosensor. (4)
11. **Industrial Mycology:** Industrial production of citric acid, alcohol, enzymes and antibiotics. (8)
12. **Culture repositories** and methods of preservation of fungal cultures; Mycological databases; Bar coding as a tool for molecular identification of fungi. (3)

Theoretical Course
BOTDSE T403.3
MYCOLOGY & PLANT PATHOLOGY (COURSE – II)

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

Course Objectives:

This course aims to teach the recent advancements in plant-pathogen interaction, defense mechanism of plants, how pathogens evade this, genes responsible for resistance, tools used in disease forecasting, and detection of pathogens. Current status & future prospect of biological

control, and fungicides and antibiotics used in agriculture will be taught with recent developments. Information about the seed borne diseases, post-harvest disease and mycotoxins will also be given to the students.

Learning Outcomes:

- Students will understand molecular basis of plant-pathogen interaction, role of different antimicrobial phytochemicals in defense and different types of resistance acquired by the plant.
- Students will know about different mechanisms of pathogen to evade host defense, and able to identify the genes involved in resistance, learn about their cloning and how these are exploited to develop transgenic disease resistant plants.
- Students will learn about cause of epidemic, computer stimulation and recent tools used in disease forecasting and detection of pathogens.
- Students will also get idea on current status & future prospect of biological control, and mode of action of fungicides and antibiotics used in agriculture and how resistance against the chemicals is developed by the pathogens.
- They will also understand how pathogens infect seeds and other post-harvest commodities and role of different mycotoxins for deterioration of these commodities.

Course Content: **(No. of Classes allotted)**

1. **Plant-Pathogen Interaction:** phenomenon of infection, recognition and signal transduction; plant innate immunity (PTI, ETI); active defense: ion efflux, oxidative burst, role of nitric oxide. (8)
2. **Molecular Aspect of Plant Disease Resistance:** role of phenolics, phytoalexins, phytoanticipins, pathogenesis related proteins (classes and functions in plant disease resistance), other defense proteins, systemin, lipoxygenase; hypersensitive reactions; systemic acquired resistance, induced systemic resistance; hypotheses of plant-pathogen recognition mechanism. (12)
3. **Fungal Evasion of Host Defense.** (4)
4. **Genetics of Pathogenicity:** types of resistance, pathogen genes: *avr*/effector, hrp, harpin, type III secretion system, plant resistance (R) genes, concept of NLR/resistosome. (8)
5. **Epidemiology of Plant Diseases**; disease pyramid: components, measurement and simulation of plant disease epidemics; forecasting and remote sensing. (4)
6. **Plant Disease Diagnosis Utilizing Molecular Tools.** (2)
7. **Development of Disease Resistant Variety** by mutation, breeding and recombinant DNA technology; cloning of resistance (R) genes and avirulence (Avr) genes; RNAi in plant pathology. (6)
8. **Biological Control:** current status, constrains and future prospect; Biopesticides. (8)
9. **Chemical Control:** Fungicides: Application and mode of action, FRAC; mechanisms of fungicide resistance; antibiotics used in plant disease control. (10)
10. **Seed Pathology:** seed borne diseases, entry, transmission, seed treatment. (6)
11. **Post Harvest Diseases:** types, causal agent and their management strategies. (6)
12. **Mycotoxins:** aflatoxin and other fungal toxins and their impact on human health. (6)

Practical Course
BOTDSE P403.3
Practical based on MYCOLOGY & PLANT PATHOLOGY (COURSE I & II)

Points: 100 **6 hours/ week**

Course Objectives:

This course aims to hands on training in estimation of plant metabolites, assay of cell wall degrading enzymes, antibiotic assay, fungal tissue culture, and to isolate of fungi from environmental samples, to extract fungal genomic DNA and it use in PCR amplification, to identify defense protein(s) through SDS-PAGE, assay of biocontrol agents and estimation of metal tolerance. Students will be guided to identify fungi and pathological specimens.

Learning Outcomes:

- Students will gain skills on quantitative assay of carbohydrate, protein and phenol and will understand how infection affects content of these metabolites.
- Students will find out optimum temperature & pH for pectinase activity of different fungal strains and sensitivities to different antibiotics for supplied plant pathogenic bacterial strains.
- Students will able to isolate fungi from soil & water samples and extract fungal genomic DNA and use it as template for amplification some specific genes used for molecular identification. They will also able to detect proteins through SDS-PAGE expressed during SAR.
- They will also gain skill to assay metal tolerance and biocontrol activity of fungal &/or bacterial isolates.
- They will also understand how to describe & identify fungal and pathological specimens collected during field study by observing symptoms & macro- &/or microscopic characters.

Course Content:

1. Determination of carbohydrate, protein and phenol contents of healthy and diseased tissues.
2. Study of factors affecting cell wall degrading enzyme activity- pH and temperature.
3. Study of sensitivity of phytopathogenic bacteria to different antibiotics.
4. Isolation of fungi from soil and water samples.
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 tolerance in fungi.
12. Biological control 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, field note book containing colour photograph of fungal specimens &fresh pathological

specimens taken during field works mentioning date and place of collection and disease, host and causal agent should be submitted at the time of term-end examination.

Suggested Readings:

1. K. Esser (Ed.), The Mycota: Vol. I -XII : Springer Verlag, Berlin
2. Kendrick, B. (2017). The Fifth Kingdom An introduction to Mycology, 4th Edition, Hackett Publishing
3. Rai, M. & Bridge, P.D. (2009). Applied Mycology, CABI
4. Carlile, M.J. (2004) The Fungi, 2nd Edition, Academic Press
5. Deacon, J. (2006). Fungal Biology, 4th Edition, Blackwell Publishing
6. Moore-Landecker, E. (1996). Fundamentals of the Fungi, 4th Edition, Prentice Hall
7. Smith, J.E. & Berry, R. (1975) The Filamentous Fungi: Industrial mycology, Wiley
8. Burnett, J. H. (1976). Fundamentals of Mycology, 2nd Edition, Edward Arnold
9. Sessa, G. Molecular Plant Immunity, Wiley-Blackwell
10. Dickinson, M. (2003) Molecular Plant Pathology, Bios Scientific Publishers, Taylor & Francis
11. Tarr, S.A.J. (1972). Principles of Plant Pathology, Macmillan Education
12. Scheffer, R.P. (1997). The nature of disease in plants, Cambridge University Press
13. Singh, R.P. & Singh, U.S. (2018). Molecular methods in Plant Pathology, Crc Press
14. Recent and seminal articles from scientific journals

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Course No.	Course name	Points	Credits	Hrs./Wk.
BOTDSE T402.4	**Palaeobotany, Palynology & Evolution (Course - I)**	**100**	**8**	**8**
BOTDSE T403.4	**Palaeobotany, Palynology & Evolution (Course - II)**	**100**	**8**	**8**
BOTDSE P404.4	**Practical based on Palaeobotany, Palynology & Evolution (Course – I & II)**	**100**	**8**	**6**
BOTDSE PW	**Project/ Review**	**100**	**8**	**6**
TOTAL (BOTDSE T402.4 + T403.4 + P404.4 + PW)		**400**	**32**	**28**

EVALUATION SCHEME-

THEORY (BOTDSE T402.4) **: Internal Assessment (20 points) + Term End Examination (80 points)**

THEORY (BOTDSE T403.4) **: Internal Assessment (20 points) + Term End Examination (80 points)**

PRACTICAL (BOTDSE P404.4)**: Internal Assessment (20 points) + Term End Examination (80 points)**

PROJECT/REVIEW : Internal Assessment (20 points) + Term End Examination (80 points)

Theoretical Course
BOTDSE T402.4
PALAEOBOTANY, PALYNOLOGY & EVOLUTION (COURSE - I)

TEE Points: 80 **Classes/ Semester: 80**

Course Objectives:

The objective of the course is to increase the understanding of the students about uses of both mega- and micro- fossils in various fields like geology, climatology, environment and ecology, hydrocarbon exploration etc.

Learning Outcomes:

Students will be acquainted with the knowledge of

- Essentials of geology in relation to Palaeobotany
- Continental drift, plate tectonics and plant fossils
- Concept, limit and extension of the Gondwana continent
- Elements of stratigraphy and time scale
- Plant fossils as palaeoenvironmental proxies & climate change event
- Microfossils and its implications
- Life as a Fuel Maker-coal and oil
- Recent perspectives in palaeobotanical research

Course Content: **(No. of Classes allotted)**

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. (10)
3. **Concept, limit and extension of the Gondwana continent:** Concepts of Gondwana continent, origin, rise and decline of Glossopteris flora with climatic inferences. (10)
4. **Elements of Stratigraphy and Time Scale:** Stratigraphic units, time scale, major fossil groups used in time scale, facies. (10)
5. **Plant Fossils as Palaeoenvironmental Proxies & Climate Change Event:** Analysis of palaeoenvironment by using plant fossil through different methods - leaf physiognomy, NLR of coexistence model, CLAMP, stomatal density and index, dendrochronology; role of plant fossils in predicting future climate change. (10)
6. **Microfossils and its Implications:** Geological occurrence and palaeoecological significance of acritarch, dinoflagellate, silicoflagellate, radiolaria, microforaminifera, ostracoda, diatom. (10)
7. **Life as a Fuel Maker-Coal and Oil:** Source of natural fuels, peat, coal and its varieties, constitution of coal, coal seams and coalfields, petroleum and oil shales, origin, migration accumulation and exploration of petroleum. (10)
8. **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. (10)

Theoretical Course

BOTDSE T403.4

PALAEOBOTANY, PALYNOLOGY & EVOLUTION (COURSE - II)

TEE Points: 80 **Classes/ Semester: 80**

Course Objectives:

This course aims to introduce evolutionary thoughts, theories, scientific provenance, and plant fossil records for exploring evolutionary histories in understanding the valuable statement of Theodosius Dobzhansky (1973) -"Nothing in biology makes sense except in the light of evolution".

Learning Outcomes:

Students will be acquainted with the knowledge of

- Emergence of evolutionary thoughts
- Genetic variations and its consequences
- Species and Speciation
- Origin of life and early Events
- Evolution, diversification and extinction of flora
- Nature's Green Revolution by the origin of C4 and CAM photosynthetic pathways
- Plant-animal interactions in geologic past and their co-evolution
- Evolutionary theories and plant fossil record

Course Content: **(No. of Classes allotted)**

1. **Emergence of Evolutionary Thoughts:** Lamarck; Darwin – concepts of variation, adaptation, struggle, fitness and natural selection, Neo-Darwinism. (10)
2. **Genetic Variations:** Origin of genetic variation; Mendelian genetics; mutations, linkage and recombination; polygenic traits, epistasis, gene - environment interaction; heritability; population genetics; molecular evolution; molecular clocks. (15)
3. **Species and Speciation:** Concepts, distractions, alternatives and differences, hybridization, reproductive barriers, polyploidy and sympatric speciation, monogenic speciation, regulatory genes and heterochrony. (15)
4. **Origin of Life and Early Events:** Origin of basic biological molecules; abiotic synthesis of organic monomers and polymers; Oparin and Haldane hypothesis; Miller experiment (1953); origin of first cell; evolution of prokaryotes; origin of eukaryotic cells; evolution of unicellular eukaryotes; anaerobic metabolism, photosynthesis and aerobic metabolism. Palaeo-Meso-Neo Archean and Proterozoic life. (15)
5. **Evolution, Diversification and Extinction of Flora:** Rise of land vegetation, diversification of floras through ages, mass extinction and plant fossil record. (10)
6. **Nature's Green Revolution:** Evolutionary rise of C4 and CAM plants, first grasses; expansion of C4 grasses. (5)
7. **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. (5)
8. **Evolutionary Theories and Plant Fossil Record:** Evolutionary theories, patterns of evolutionary change, driving forces for evolutionary change. (5)

Practical Course

BOTDSE P404.4

Practical based on PALAEOBOTANY, PALYNOLOGY & EVOLUTION (COURSE I & II)

Points: 100 **6 hours/ week**

1. Geological and geographical mapping of different sedimentary basins, coal and petroliferous basins in India.
2. Demonstration of traditional and recent techniques adopted in palaeobotanical and palynological research.
3. Study of fossil types and modes of preservation.
4. Morpho-anatomical study of plant fossils through geological ages.

5. Extraction of spores and pollen grains from coal, lignite, peat using suitable techniques, microscopic study, analysis, data representation and interpretation for reconstruction of palaeovegetation and depositional environment.
6. Visit to Palaeobotany Gallery of Indian Museum/ University Laboratory/Fossil Field.

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

Suggested Readings:

1. Brasier, M.D. Microfossils. George Allen and Unwin, London.
2. Cleal, C.J., and Thomas B.A. 1999. Plant Fossils. The History of Land Vegetation. Woodbridge, Boydell Press, Woodbridge, VA.
3. Duff P. MCL. 1992. Holmes' Principles of Physical Geology. ELBS with Chapman & Hall
4. Duff P. MCL. 1992. Holmes' Principles of Physical Geology. ELBS with Chapman & Hall
5. Erdtman, G. 1969. Handbook of Palynology. Munksgaard, Copenhagen.
6. Futuyma, D. J. 1998. Evolutionary Biology. Sinauer Associates.
7. Hall Brian K. and Hallgrimsson Benedikt. 2014. Strickberger's Evolution. Jones and Bartlett India Pvt. Ltd.
8. Jones, T.P. and Rowe N.P. 1999. Fossil Plants and Spores: modern techniques. The Geological Society, London.
9. Kumar R. 2011. Fundamentals of Historical Geology and Stratigraphy of India. New Age International Publishers.
10. Levin, H.L. 1981. Contemporary Physical Geology.
11. Meyen, S.V. 1987. Fundamentals of Palaeobotany. Chapman & Hall, New York.
12. Moore, P.D., Webb J.A. and Collinson M.E. 1991. Pollen analysis. 2nd Edition. Oxford (Blackwell Scientific Publications).
13. Niklas J. Karl. 1999. The evolutionary biology of plants. The University of Chicago Press.
14. Page, R. D. M. and Holmes E. C. 1998. Molecular Evolution: A Phylogenetic Approach, Blackwell.
15. Ridley, M. 2003. Evolution, Blackwell.
16. Senger, R. 1999. Encyclopaedia of Palaeontology. Fitzroy Dearborn Publ.
17. Snustad Peter D. and Simmons J. Michael. 2000. Principle of Genetics. John Wiley & Sons, Inc.
18. Stach, E. *et al*. 1982. Coal petrology.
19. Stewart, W.N., and Rothwell G.W. 1993. Palaeobotany and the Evolution of Plants, 2nd ed. Cambridge University Press, New York.
20. Surange, K.R., R.N. Lakhanpal and D.C. Bharadwaj. 1974. Aspects and Appraisal of Indian Palaeobotany. Birbal Sahni Institute of Palaeobotany, Lucknow.
21. Taylor, T.N., Taylor E.L. and Krings M. 2009. Palaeobotany- The Biology and Evolution of Fossil Plants. Elsevier.
22. Thomas, B.A., and Spicer R.A. 1987. The Evolution and Palaeobiology of Land Plants. Croom Helm, London (Dioscorides Press, Portland, OR).
23. Traverse, A. 1988. Paleopalynology.Springer
24. Willis, K.J., and McElwain J.C. 2002. The Evolution of Plants. Oxford University Press, New York.

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Course No.	Course Name	Points	Credits	Hrs./Wk.
BOTDSE T402.5	Phycology (Course - I)	100	8	8
BOTDSE T403.5	Phycology (Course - II)	100	8	8
BOTDSE P404.5	Practical based on Phycology (Course – I & II)	100	8	6
BOTDSE PW	Project/ Review	50	8	6
TOTAL (BOTDSE T402.5 + T403.5 + P404.5 + PW)		400	32	28

EVALUATION SCHEME-
THEORY (BOTDSE T402.5) **: Internal Assessment (20 points) + Term End Examination (80 points)**
THEORY (BOTDSE T403.5) **: Internal Assessment (20 points) + Term End Examination (80 points)**
PRACTICAL (BOTDSE P404.5)**: Internal Assessment (20 points) + Term End Examination (80 points)**
PROJECT/REVIEW : Internal Assessment (20 points) + Term End Examination (80 points)

Theoretical Course
BOTDSE T402.5
PHYCOLOGY (COURSE – I)

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

Course Objectives:

To make students understand the classical concepts of the polyphyletic group – algae, and be able to classify them within a phylogenetic framework; to elucidate the general characters of different groups of algae; to make clear the domains of algal genetics and algal physiology, especially in terms of photosynthesis and responses to stress;to give an insight into the fossil history of this group.

Learning Outcomes:

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

- Provide an overview of algal systematics and theories explaining chloroplast evolution and algal origin and apply this knowledge in explaining the evolutionary significance of algae and use it as a basis for understanding the evolutionary pathways to other plant groups.
- Describe the general characteristics of important groups of algae, and furthermore compare and contrast these characteristics with different forms.
- Address the classical concepts of genetics, physiology, biochemistry of the algae and explain them.
- Elucidate the fossil history of the algal groups.

Course Content: **(No. of Classes allotted)**

1. **Morphology and Ultra-structure 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 Phylogenyof the following algal groups:** Prochlorophyta, Glaucophyta, Euglenophyta, Apicomplexa, Cryptophyta, Chlorarachniophyta, Heterokontophyta (Chrysophyceae, Eustigmatophyceae, Bacillariophyceae); Prymnesiophyta (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 acquisition mechanisms; Light harvesting systems;Photosynthesis in marine macroalgae; Photosynthesis in symbiotic algae. (12)
7. **Algal Pigments:** Pigment diversity and chemotaxonomy; Production and application of algal bio-colorants - Phycocyanin, Phycoerythrin, allophycocyanin, Astaxanthin, & beta-carotene along with their commercial potentials. (12)
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. (4)

Theoretical Course

BOTSDE T403.5

PHYCOLOGY (COURSE – II)

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

Course Objectives:

To make students understand the applied aspects of the group algae, and also their roles, responses and importance within an ecological framework; to elucidate the nuances of algal culture; to make clear the domains of bio-geochemical roles and biotechnological applications, especially in terms of limiting nutrients, pigments and nanotechnology; to give an insight into seaweed utilization.

Learning Outcomes:

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

- ❖ Provide an overview of algal culture techniques.
- ❖ Elucidate the biotechnological application of algae in terms of secondary metabolite production and application and nanotechnology along with their commercial potentials.
- ❖ Describe the role of algae in important biogeochemical cycles of the earth.
- ❖ Explain the components of algal/ phytoplankton ecology and the nutrient uptake mechanisms.
- ❖ Explore and explain the nuances and potentials of sea-weed cultivation.

Course Content: **(No. of Classes allotted)**

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. **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)
3. **Biogeochemical Role:**Limiting nutrients*;* Algae in - carbon cycle, nitrogen cycle, sulfur cycle and silicon cycle; Production of halocarbon compounds. (6)
4. **Biotic Associations:** In food webs, as parasites or pathogens, as epibionts and in mutualistic symbiosis. (6)

5. **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)
6. **Algal Ecology:** Macroalgae, periphyton, marine and turf forming algae and terrestrial algae. (5)
8. **Algal Response to Stress:** Salinity, desiccation, temperature, light intensity, UV-B radiation; Production and application of stress products. (10)
9. **Algal Pollution:** Freshwater and marine pollution; monitoring of pollutants; strategies for controlling eutrophication; phyco-remediation. (5)
7. **Seaweeds and their Uses:** Historical perspectives and linkages with modern economy and food security. (2)

Practical Course
BOTDSE P404.5

Practical based on PHYCOLOGY (COURSE I & II)

Points: 100 **6 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. 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.
3. Extraction and estimation of various algal pigments: chlorophyll, carotenoid and phycocyanin.
4. Cleaning of diatom frustules for morphometric analysis ofthe valves
5. Culturing algae in the laboratory and growth measurements.
6. Algae immobilization exercise - preparation of algal beads.
7. Algal cytology study.
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.

Suggested Readings:

1. Brodie, Juliet & Jane Lewis (2007). Unravelling the algae–the past, present and future of algal systematics. CRC Press.
2. C.D. Amsler (2008). Algal Chemical Ecology. Springer.
3. R.A. Andersen (2005). Algal Culturing Techniques., Elsevier Academic Press, London.
4. S.P. Adhikary (2006). Blue green algae: Survival strategies in diverse environment. Pointer Publishers, Jaipur.
5. S.N. Bagchi, D.Kleiner & P. Mohanty (2010). Protocols on algal and cyanobacterial research. Narosa Publishing House, New Delhi.
6. E.G. Bellinger & D.C. Sigee (2010). Fresh water algae–Identification and use as bioindicators. Wiley Blackwell.

7. Bela Bhatia & M.R. Vijayaraghavan (1997). Red Algae:Structure, Ultrastructure and Reproduction. APH Publication.
8. N.G.Carr & B.A. Whitton (eds.) (1982). The biology of cyanobacteria. Blackwell Scientific Publications, Oxford.
9. H.C. Bold & M.J. Wynne (1985). Introduction to the algae: Structure and Reproduction. Prentice-Hall.
10. V. Chapman (1970). Seaweeds and their uses. Second Edition. J. Methuen & Co. Ltd. London.
11. G.E. Fogg (1953). The Metabolism of algae. Methuen& Co., London.
12. Graham, Linda, J.M. Graham & L.W. Wilcox (2009). Algae. Benjamin Cummings from Pearson Education.
13. R.E. Lee (2008). Phycology. Cambridge University Press.
14. Lewin, R.A. (1976). The genetics of algae. University of California Press.
15. C.M. Palmer (1977). Algae and water pollution. USEPA, Cincinnati.
16. Ray, S. (2006). Cyanobacteria. New Age International Publishers, New Delhi.
17. K.S. Rowan (1989). Photosynthetic pigments of algae. Cambridge University Press, USA.
18. C. Schlieper (1972). Research Methods in Marine Biology. Sidgwick and Jackson Ltd.,London.
19. J. Seckbach (ed.) (2007). Algae and cyanobacteria in extreme environments. Springer, Netherlands.
20. Sournia, A. (ed.)(1978). Phytoplankton Manual. UNESCO, Paris.
21. Stoermer, E.F. & J.P. Smol (2004). Diatoms: Applications for environmental and earth science. Cambridge University Press, UK.
22. C. VanDenHoek, D.G. Mann & H.M. Jahns (2009). Algae–An introduction to phycology. Cambridge University Press.
23. M.R. Vijayaraghavan & S. Kumari (1995). The Chlorophyta: Structure, Ultra-structure & Reproduction. Published by Bishen Singh Mahendra Pal Singh.

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Course No.	Course Name	Points	Credits	Hrs./Wk.
BOTDSE T402.6	**Plant Physiology, Plant Biochemistry & Plant Molecular Biology (Course-I)**	**100**	**8**	**8**
BOTDSE T403.6	**Plant Physiology, Plant Biochemistry & Plant Molecular Biology (Course - II)**	**100**	**8**	**8**
BOTDSE P404.6	**Practical based on Plant Physiology, Plant Biochemistry & Plant Molecular Biology (Course-I & II)**	**100**	**8**	**8**
BOTDSE PW	**Project/ Review**	**100**	**8**	**6**
TOTAL (BOTDSE T402.6 + T403.6 + P404.6 + PW)		**400**	**32**	**28**

EVALUATION SCHEME-

THEORY (BOTDSE T402.6) **: Internal Assessment (20 points) + Term End Examination (80 points)**

THEORY (BOTDSE T403.6) **: Internal Assessment (20 points) + Term End Examination (80 points)**

PRACTICAL (BOTDSE P404.6)**: Internal Assessment (20 points) + Term End Examination (80 points)**

PROJECT/REVIEW : Internal Assessment (20 points) + Term End Examination (80 points)

Theoretical Course
BOTDSE T402.6

PLANT PHYSIOLOGY, PLANT BIOCHEMISTRY & PLANT MOLECULAR BIOLOGY (COURSE – I)

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

Course objective: **(No. of Classes allotted)**

The course imparts the key physiological, biochemical and molecular biological processes that occur in plants. The contents of the course deal with biosynthetic pathways of different phytochemicals and illustrate the different approaches to identify and characterize them. The contents also highlight the structure-function aspects of different molecular complexes. The course focuses on molecular mechanisms of signal transduction pathways driven by various plant hormones and the developmental progression of flowering influenced by environmental cues.

Learning Outcomes:

On successful completion of this course, students should be able to –

- ❖ Understand the metabolic pathways for biosynthesis of various phytoconstituents.
- ❖ Implement different methodologies to characterize Phyto-compounds.
- ❖ Analyze molecular mechanisms underlying different physiological processes.

Course contents:

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. **Methods of separation, purification and characterization of plant products:** Chromatography, Electrophoresis, Centrifugation, Spectroscopy, X-ray diffraction. (14)
4. **Photosystem-I**: Function and physiology. (5)
5. **Plant photoreceptors**: Structure and function. (5)
6. **Molecular mechanism of flowering:** Gene expression during flower development, floral induction and control of flowering. (5)
7. **Protein transport in the Chloroplast:** Mechanism of protein import and routing in Chloroplast. (5)
8. **Auxin signaling:** Transcriptional and non-transcriptional regulations in response to Auxin. (4)
9. **Molecular mechanisms of gibberellin signaling in higher plants:** Regulators of gibberellin signaling, model for gibberellin signaling, cross-talks with phytochrome interacting factors (PIFs) and other plant hormones. (5)
10. **Cytokinin signaling in plants:** Cytokinin two-component signaling circuitry, interplay between cytokinin and auxin, role of cytokinin in plant immunity, abiotic stress and senescence. (5)
11. **Salicylic acid and Strigolactones in plants:** Biosynthesis, physiological roles and signaling mechanisms. (5)
12. **Molecular biology of fruit ripening and maturation:** Fruit development and ripening, role of ethylene in ripening. (5)

Theoretical Course
BOTDSE T403.6

PLANT PHYSIOLOGY, PLANT BIOCHEMISTRY & PLANT MOLECULAR BIOLOGY (COURSE – II)

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

Course Objectives:

The course aims to educate students on methods of plant products separation by biophysical techniques, signaling with growth regulators, development of aging process and senescence, special bioresidues in stress tolerance, photoreceptors and light transmission etc. The course

further describes stress tolerance through gene regulation, radioactive tracer technique and light harnessing mechanism.

Learning Outcomes:

- The students will be enriched with different techniques based on biophysical and biochemical methods, separation and chemical analysis of their molecular structure. The course will also describe the designing of biomolecules in application of specific plant pathways.
- The students will be benefitted with kinds of signal transduction, path and messenger concept, secondary messenger, kinases and phosphatases in delineation to increase their understanding for signaling cascades. The signaling in plant aging and senescence through major physiological activities like fruit ripening and involvement of hormonal regulation thereon. The receptor like two component system, photoreceptor, sensing mechanism and their implication on biotechnology would be easier for learner to grasp through these classes.
- With the course offered students would be benefitted about plant-environment interaction particularly, those are the imposition of environmental extremities such as water deficits, salt, deficiency of light, acquisition of xenobiotics etc. The plants potential through the expression of genes and their analysis techniques and annotation would be the other important point that the course deals in plant growth and development. Moreover, use of radioactivity particularly through tracer technique would be presented as modern-state-of-the-art.
- Students will be enriched the major biophysical mechanism in plants like photobiology, its receptors, signaling along with utilization in photosynthesis, flowering, vernalization and hormonal basis of photobiological regulation.

Course Content: **(No. of Classes allotted)**

1. **Phenomics technique** in plants developmental expression. (3)
2. **Ca^{2+} signaling** in higher plants. (5)
3. **One carbon metabolism** in higher plants. (6)
4. **Organization and regulation of mitochondrial respiration** in plants. (6)
5. **Alteration of gene expression** in higher plants due to environmental stress. (6)
6. **Assimilation of sulphur, phosphate, cation and oxygen**. The energetics of nutrient uptake. (6)
7. **Genomics and proteomics**. (12)
8. **Photorespiration, C_4 photosynthesis and CO_2 enrichment technique**. (6)
9. **RUBISCO:** structure and function. (6)
10. **Seed germination and vigor in plants**, Fundamental of Plant growth and differentiation. (6)
11. **Principle and applications of tracer techniques** in biology and labeling study. (6)
12. **ABA-** emergence of core signaling system in plants. (6)
13. **Molecular structure of photosystem- II** and measurement of efficiency by Pulsed Interleaved Excitation (PAM) analysis. (6)

Practical Course

BOTDSE P404.6

Practical based on PLANT PHYSIOLOGY, PLANT BIOCHEMISTRY & PLANT MOLECULAR BIOLOGY (COURSE I & II)

Points: 100 **6 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.

Suggested Reading:

1. Nelson D. L.and Cox M. M. (2021) Lehninger Principles of Biochemistry(8th edition),Macmillan Publishers Ltd., London, UK
2. Taiz L., Zeiger, E, Moller, I. M. & Murphy, M. (2015) Plant Physiology and Development, 6th edition, Sinauer Associates, USA.
3. Taiz L. and Zeiger, E. (2010) Plant Physiology, 5th edition, Sinauer Associates, USA.
4. Jones R., Ougham H., Thomas H. and Waaland S. (2012) The Molecular Life of Plants, Wiley-Blackwell, USA.
5. Davies P. J. (2004) Plant Hormones: Biosynthesis, Signal Transduction, Action. 3rd edition, Kluwer Academic Publisher, Dordrecht, The Netherlands.
6. Jordan B. R. (2006) The Molecular Biology and Biotechnology of Flowering, 2nd Edition, CAB International, Oxfordshire, U.K.
7. Dey P.M. and Harborne J.B. (1997) Plant Biochemistry, Academic press.
8. Wilson, K., Walker, J (2006). Wilson and Walker's Principles and Tecniques of Biochemistry and Molecular Biology.
9. Buchanan, B., Gruissem, W., Jones, R., (2000) Biochemistry and Molecular Biology of Plants. IK publishers, New Delhi, India.

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Course No.	Course Name	Points	Credits	Hrs./Wk.
BOTDSE T402.7	**Pteridology (Course - I)**	**100**	**8**	**8**
BOTDSE T403.7	**Pteridology (Course - II)**	**100**	**8**	**8**
BOTDSE P404.7	**Practical based on Pteridology (Course – I & II)**	**100**	**8**	**6**
BOTDSE PW	**Project/ Review**	**100**	**8**	**6**

TOTAL (BOTDSE T402.7 + T403.7 + P404.7 + PW)	**400**	**32**	**28**

EVALUATION SCHEME-

THEORY (BOTDSE T402.7)**: Internal Assessment (20 points) + Term End Examination (80 points)**
THEORY (BOTDSE T403.7) **: Internal Assessment (20 points) + Term End Examination (80 points)**
PRACTICAL (BOTDSE P404.7)**: Internal Assessment (20 points) + Term End Examination (80 points)**
PROJECT/REVIEW : Internal Assessment (20 points) + Term End Examination (80 points)

Course Objectives:

To disseminate the knowledge about the pteridophytes or seedless vascular plants' biology, historical spectrum of the subject and the contributors of India and abroad and present position of this subject.

Learning Outcomes:

Students will be more enriched with the pinpoint knowledge of

- Systematics and evolution of the pteridophytes, classification approach of the workers from present to past, biology of the organism in detail
- Ecology and conservation needs of the plant, ferns and economy
- Floristic distribution in India in special focus to West Bengal, historical knowhow of the subject

Theoretical Course
BOTDSE T402.7

PTERIDOLOGY (COURSE – I)

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

Course Content: **(No. of Classes allotted)**

1. **Pteridophyta- an Introduction**, first vascular land plants and its evolution in land, phylogeny and trends of evolution in the groups, criteria of classification, evolution of classification system from past to present, classification outline of PichiSermolli (1977), Smith (2006), PPG-I (2016). (10)
2. **Taxonomic treatment of family Lycopodiaceae, Ophioglossaceae and Psilotaceae**, characteristics of major fern families. (10)
3. **Anatomical Specialization in Pteridophytes:** major tissue systems and evolution, vascular specialization in different organsand evolutionary trends; ontogeny and interrelationships of stomata. (10)
4. **Fossil pteridophytes:** Distribution of fossil components through different geological periods in special reference to India. (10)
5. **Palynology:** Spore types and spore characters of different extant fern families (Psilotaceae, Lycopodiaceae, Selaginellaceae, Isoetaceae, Equisetaceae, Ophioglossaceae, Marattiaceae, Osmundaceae, Cyatheaceae, Pteridaceae, Parkeriaceae, Dennstaedtiaceae, Hymenophyllaceae, Thelypteridaceae, Polypodiaceae, Masileaceae, Salviniaceae), spore germination and regulatory factors, spore viability. (10)
6. **Cytogentics and Speciation:** chromosome number of different fern families, polyploidy and its nature, hybridization, speciation in ferns, species complex, apospory, apogamy and apomixis, alternation of generation, fern genetics and reproduction. (10)
7. **Ferns and Vascular Plant Life Cycle:** homosporous cycle, agamospory, apogamous cycle, free-sporing heterospory, relationship between heterospory and anisospory, apospory. (10)

8. **Fern Gametophyte:** gametophyte characters as taxonomic marker, development pattern in different types, morphotypes: evolutionary trends and ecological significance, photoresponses in fern gametophytes, gametophyte culture: method, composition of media, gametogenesis, male gamete and evolutionary trends, fertilization. (10)

Theoretical Course
BOTDSE T403.7

PTERIDOLOGY (COURSE – II)

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

Course Content: **(No. of Classes allotted)**

1. **Distribution of different types of Secondary Metabolites** in different families of pteridophtes and their role as chemotaxonomic marker. (10)
2. **Fern Ecology**, biogeography and conservation biology: diversity and distribution in different environment, dispersal and vicariance, endemism, conservation strategies, *ex situ* and *in situ* conservation, regional and ecosystem level conservation, IUCN red list, CITES. (10)
3. **Nutrient Ecology** of ferns. (5)
4. **Xeric Ferns:** drought adaptation and desiccation tolerance. (5)
5. **Interaction of Ferns with other Organism:** fossil evidence, interaction with fungi, insects and animals. (4)
6. **Ferns as Weeds and their Management:** *Pteridium, Salvinia, Lygodium* and other alien terrestrial and aquatic ferns, public awareness and control measures. (6)
7. **Rules of ICBN**, problems on nomenclatural types, importance and solving of nomenclatural issues, world herbaria, virtual herbarium, regional flora and manual, continental flora. (10)
8. **Ferns and Economy:** Ethnomedicine and modern medicine, garden ferns and cultivation, fern as food and fodder, local economy-critical analysis and entrepreneurship development (10)
9. **Pteridologist of India and their Contribution**, history of pteridology in global aspect, present position of India in fern research, a critical analysis. (10)
10. **Pteridophytic Flora** of eastern Himalaya, western-Himalaya and North-East Himalaya, ferns of Western Ghats, ferns of lower Gangetic plains and arid West Bengal. (10)

Practical Course

BOTDSE P404.7

Practical based on PTERIDOLOGY (COURSE I & II)

Points: 100 **6 hours/ week**

1. Work out and description of pteridophytes from fresh collection, wet and dry preserved material, identification upto species level using regional flora and manual.
2. Maceration of tracheary elements, study of vascular tissue, different types of steles in representative families; adult morphotypes of stomata by leaf clearing and peeling methods.
3. Cytological study of some local material.
4. Spore study and measurement.
5. Demonstration of in vitro gametophyte culture method,
6. Staining techniques and preparation of permanent and semipermanent slides
7. Visit of local nurseries and collection of local cultivation method of garden ferns, concept to develop own nursery, methods and practice

8. Field tour (long and short), collection of extinct and extant material, dry(poisoning, killing and herbarium preparation) and wet preservation method of living specimen.

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.

Suggested Readings:

1. Dyer A.F. 1979. Experimental Biology of Ferns. Academic press. ISBN: 0-12-226350-2
2. Tryon A. F and Lugardon B 1990. Spores of the pteridophyta: Surface, Wall Structure, and Diversity Based on electron microscope studies. Springer –verlag. ISBN: 0-387-97218-8
3. Ogura Y. 1972. Comparative anatomy of vegetative organs of the pteridophytes. Second revised edition ISBN: 3-443 14006 8
4. Kramer K.U. and Green P.S. (Eds) The families and genera of vascular plants: Pteridophytes and Gymnosperms. Springer –verlag
5. Gifford M.E. and Foster A.S. 1988 Morphology and Evolution of Vascular Plants. W H Freeman and Company
6. Stewart W. N and Rothwell G.W. Paleobotany and the evolution of plants. Cambridge University Press. Second Edition
7. Willis, K.J., and McElwain J.C. 2002. The Evolution of Plants. Oxford University Press, New York.
8. Taylor E.L., Krings M, and Taylor T.N. 2009. Paleobotany: The biology and evolution of fossil plants

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

BOTDSE T405.1	Advanced Immunology
BOTDSE T405.2	Advanced Pteridology
BOTDSE T405.3	Mushroom Biology

Course No.	Course Name	Points	Credits	Hrs./Wk.
BOTDSE T405.1	**Advanced Immunology**	**50**	**2**	**2**

EVALUATION SCHEME – THEORY: Internal Assessment (10) + Term End Examination (40)
TEE: 40 points

Theoretical Course
BOTDSE T405.1
ADVANCED IMMUNOLOGY

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

Course Objectives:
The candidate will gain knowledge about immunity, organs of immunity and cells involved; Types of antigens and properties; immunoglobulin – types; MHC and its significance; molecular and clinical immunology as well as immune regulatory mechanism.

Learning Outcomes:

- Knowledge and Understanding: Identify and summarize the current status of knowledge within areas of cellular and molecular immunology;
- Understand normal regulation of immunity and how aberrations in the regulation can lead to immunological diseases;
- Understand the principles of immunomodulatory treatment and the role of the immune system in development of tumours
- Competence and Skills: Plan and implement a given laboratory experiment on immune responses *in vitro* and evaluate and interpret the generated data
- Judgement and Approach: Summarize, present, and evaluate current research in immunology in order to discuss new hypotheses within the area.

Course content: **(No. of Classes allotted)**

1. **Modern Immunology:** Antigen presentation; Secondary signaling, co-stimulation, Cell signaling in immune response; DC activation, B cells as APC, experimental models in APC. Complements-Lectin pathway. (7)
2. **Molecular immunology:** Peptide epitopes, T cell B cell antigenic properties, prediction of T and B cell epitopes, Chimeric peptides, polytope vaccines, Major Histocompatibility Complex, Polymorphism transplantation. (7)
3. **Clinical Immunology:** Cytokines: properties, receptor, antagonists, diseases, Therapeutic use of cytokines Experimental immunology: Vaccine development (Recombinant, Combined and polyvalent vaccines), Antigen Antibody reactions in diagnostics. Cancer Immunology, Transplantation immunology. (12)
4. **Effector Mechanisms:** Mucosal immunity, Peyer's patches, gut barriers, oral immunization, Oral tolerance, Cytotoxic response, ADCC, NK cells, CTL, Th, T regulation, Immunoregulation, anergy, tolerance, anti idiotype, Mechanisms of antiviral innate immune response. (7)
5. **Immune Regulation Mechanisms:** Brief account on immuno-induction, immuno-suppression, immuno-tolerance, immuno-potentiation. (7)

Suggested Readings:

1. Richard Coico, Geoffrey Sunshine, Eli Benjamini. Immunology – A Short Course. Wiley-Liss, New York. 5th ed., 2003.
2. Ivan M. Roitt, J. Brostoff and D. K. Male, Immunology, Gower Medical Publishing, London.1993
3. Janis Kuby, Immunology, II edition. W. H. Freeman and Company, New York. 1993
4. Pravash Sen. Gupta, Clinical Immunology. Oxford University Press. 2003.
5. Clark WR, The experimental foundations of modern immunology. John Wiley and Sons Inc. New York. 1991.

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Course No.	Course Name	Points	Credits	Hrs./Wk.
BOTDSE T405.2	**Advanced Pteridology**	**50**	**2**	**2**

EVALUATION SCHEME – THEORY: **Internal Assessment (10) + Term End Examination (40)**
TEE: 40 points

Theoretical Course

BOTDSE T405.2

ADVANCED PTERIDOLOGY

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

Course Objectives: To elaborate the concept of amalgamation of different branches of plant science in general and utilization of ferns as experimental tool in the different field of plant science in particular.

Learning Outcomes:

Students will be able to learn

- the recent advancement of pteridology.
- How the present day researcher utilizing the fern as model organism in different experiment of cell and molecular biology or in the experiment of genetics and environmental biotechnology.
- The progress of modern medicine and ethnic people contribution**.**

Course Content: **(No. of Classes allotted)**

1. **Recent Approaches of Fern Classification:** A brief outline of classification and characteristics up to family level, phylogeny and evolutionary relationships among major lineages. (2)
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, aerobiology of pteridophyte spores. (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. (7)
7. **Model fern *Ceratopteris richardii*** and its application in the understanding of cellular and molecular genetic pathways. (5)

Suggested Readings:

1. Ranker T.A. and Haufler C.H. 2008. Biology and evolution of ferns and Lycophytes. Cambridge University Press. ISBN: 978-1-4410-7161-6

2. Fernandez H, Kumar A, Revilla M. A. 2010. Working with ferns: Issues and Applications. Springer. ISBN: 978-0-521-87411-3

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Course No.	Course Name	Points	Credits	Hrs./Wk.
BOTDSE T405.3	**Mushroom Biology**	**50**	**2**	**2**

EVALUATION SCHEME – THEORY: Internal Assessment (10) + Term End Examination (40)
TEE: 40 points

Theoretical Course

BOTDSE T405.3

MUSHROOM BIOLOGY

TEE Points: 40 **Classes/ Semester: 40**

Course Objectives:

This course aims to enhance understanding of students about different groups of mushrooms, the basic and molecular aspects of fruiting body development, poisonous & edible forms, their pharmaceutical uses, steps involved in cultivation of different mushrooms, and how to improve mushroom crops.

Learning Outcomes:

- Students will learn about variation of mushroom structure, parts of taxonomic importance.
- Students will understand how mushroom fruiting body develops and hormonal & genetic factors associated.
- They can discern poisonous & edible mushrooms and learn their nutritive & medicinal values.
- Students will also gain knowledge about mushroom cultivation procedure, crop management and crop improvement.

Course Content: **(No. of Classes allotted)**

1. **Mushroom:** An introductory idea, variation in morphotypes, macroscopic and microscopic features used in morphological description. (3)
2. **Fruiting Body Development:** Stages, triggering factors, morphogens, genetic control. (5)
3. **Poisonous mushrooms** and their effects on human being. (4)
4. **Edible mushrooms:** Identification and nutrition value. (2)
5. **Mushroom as medicine** and other biotechnological uses, ethno-mycological uses. (5)
6. **Mushroom cultivation technology:** Infrastructure and equipments; spawn, preparation, technique of spawning; compost and composting; cultivation of button mushroom, oyster mushroom, paddy straw mushroom; mushroom processing. (17)
7. **Diseases of mushroom;** crop management. (2)
8. **Techniques for improvement of mushroom crops.** (2)

Suggested Readings:

1. Zied, D.C. & Pardo-Gimenez, A. (2017). Edible and Medicinal Mushrooms: Technology and Applications, Wiley-Blackwell
2. Miles, P.G. & Chang, S.T. (1997). Mushroom Biology: concise basics and current developments, World scientific
3. Archya, K., Roy, A., Sarkar, J. (2020). Mushroom cultivation technology, Techno World.

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