ST. ALBERT'S COLLEGE ERNAKULAM

(AUTONOMOUS)

Affiliated to Mahatma Gandhi University, Kottayam, Kerala

SYLLABUS FOR POSTGRADUATE PROGRAMME

MASTER OF SCIENCE IN BOTANY

UNDER CREDIT SEMESTER SYSTEM

(WITH EFFECT FROM 2022 ADMISSION)

Syllabus of M.Sc. BOTANY

Proposed by the Board of Studies on 26-02-2022

Dr. Siju M. Varghese

Chairman, Board of Studies

Approved by the Academic Council on

17-03-2022

Dr. M. A. Solomon

Chairman, Academic Council.

Adopted by the Governing Council on 29-03-2022

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Chairman, Governing Council

Board of Studies

Sl.No:	Name	Designation	Qualification
Chairman : (Head of the Department concerned)			
1	Dr. Siju M. Varghese	Assistant Professor and HoD	Ph.D.
Entire faculty			
1.	Dr. Siju M. Varghese	Assistant Professor and HoD, Department of Botany, St. Albert's College (Autonomous), Ernakulam	Ph.D.
2.	Dr. J Jameson	Associate Professor, Department of Botany, St. Albert's College (Autonomous), Ernakulam	Ph.D.
3.	Dr. K. Madhusudhanan	Assistant Professor, Department of Botany, St. Albert's College (Autonomous), Ernakulam	M. Phil., Ph.D.
4.	Smt. Drishya K. Reghuvaran	Assistant Professor, Department of Botany, St. Albert's College (Autonomous), Ernakulam	M.Sc.
5.	Smt. Mary Joseph	Assistant Professor, Department of Botany, St. Albert's College (Autonomous), Ernakulam	M.Sc.
6.	Dr. Anna Ancy Antony A.	Assistant Professor, Department of Botany, St. Albert's College (Autonomous), Ernakulam	Ph.D.
7.	Dr. Anisha S.	Assistant Professor, Department of Botany, St. Albert's College (Autonomous), Ernakulam	Ph.D.
Experts in the Subject			
1.	Dr. E. A. Siril	Professor, Department of Botany, University of Kerala.	Ph.D.
2.	Dr. Jos T. Puthur	Professor & Head, Department of Botany, University of Calicut.	Ph.D.

Nominee of Vice Chancellor			
1.	Dr. Jomy Augustine	Professor, Department of Botany, St. Thomas College, Pala.	Ph.D.
Placement Representative.			
1.	Sri. Jose P.	Corporate Sector MD and Proprietor National Nursery, Trichur. (Garden & Nursery)	
Meritorious alumnus			
1.	Dr. Stephen Sequeira	Assistant Professor, Maharaja's College (Autonomous), Ernakulam	Ph.D.
Experts from outside whenever special courses of studies are to be formulated			
1.	Dr. Vinoth Thomas	Scientist, Rubber Board of India, Kottayam	Ph.D.
2.	Mr. Nikesh R	Agricultural Assistant, Neriamangalam, Kerala	M.Sc.
Other Teachers of the Faculty			
1.	Dr Krishnakumar KS	Assistant Professor, Department of Chemistry, St. Albert's College (Autonomous), Ernakulam	Ph.D.
2.	Dr. Bijoy VM	Associate Professor, Department of Fisheries and Aquaculture, St. Albert's College (Autonomous), Ernakulam	Ph.D.

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Preface

The syllabus is a key document of a programme that depicts the actual extent and depth of learning intended for the students. St. Albert's College (Autonomous) had adopted the PG syllabi introduced by Mahatma Gandhi University, Kottayam in 2019. In tune with the changing scenario in higher education, St. Albert's College (Autonomous) decided to go with the revision of the syllabi of all its Post-graduate programmes so as to introduce new and revised PG syllabi from the academic year 2022-23 onwards. The regulations of MG University were adopted from 2020 onwards and the same have been followed in the new revised syllabus. The Department of Botany took the necessary steps towards the revision of its PG syllabus. All attempts were made to make the syllabus well-equipped to cater to the contemporary demand of both the academia as well as the job market. Brainstorming sessions within the Department and later with the external experts and members of Board of Studies helped immensely in appropriately realising the needs of the present day education and also the ongoing trends in the subject. It also helped in ensuring that the syllabus confirmed to the general guidelines of the curriculum for the post-graduate programmes. Prior to the BoS meetings, discussions were held among the faculty members in order to chalk out a preliminary plan of action and also to find out areas where more attention and inputs were needed. All these efforts helped in shaping up a syllabus as per the need.

It is to be mentioned that the contents of the syllabus have been finalised keeping in mind the relevance of the outcomes, which is the guiding principle of the present day education system. The emphasis on outcomes has been closely followed while doing the revision so as to ensure that the respective objectives and outcomes stay aligned properly. It is believed that the revised syllabus will be significant in ensuring learning of students and also in developing their skills in the area of plant sciences which will to an extent help in improving their employability.

The contributions of all the members of the Board of Studies of Botany, especially the external ones is deeply appreciated and acknowledged at this juncture. The inputs and deliberations in the BoS have come a long way in bringing out the final revised syllabus.

Acknowledgement

The decision to revise the syllabi of the Post Graduate programmes of St. Albert's College (Autonomous) had been taken at the very beginning of the academic year 2021-22. Towards this goal, a number of discussions and meetings were initiated, both at the Departmental level and at the level of the Board of Studies. The completion of the revision process and finalization of the contents of the syllabus is indeed a great job accomplished. The contributions of all those involved through the various stages of the entire process is being appreciated. I am thankful to the Management and Principal of St. Albert's College (Autonomous) for putting forth the idea of a revised PG syllabus from the academic year 2022-23 onwards and also for rendering all kinds of support for the smooth progress and completion of the revision process.

The suggestions given by the members of the Board of studies had been crucial in upkeeping the standards of the syllabus. Despite their busy schedules, all the members of the BoS whole heartedly participated in the process of revision. The inputs from the external members, Dr. E A Siril (Professor, Department of Botany, University of Kerala), Dr. Jos T Puthur (Professor& Head, Department of Botany, University of Calicut), Dr. Jomy Augustine (Associate Professor, St. Thomas College, Pala), Dr. Stephen Sequeira (Assistant Professor, Maharaja's College (Autonomous), Ernakulam), Dr. Vinoth Thomas (Scientist, Rubber Research Institute of India, Kottayam), Sri Nikesh R (Agricultural Assistant, Neriamangalam, Kerala) and Sri Jose P (MD, National Nursery, Trichur) helped in making the syllabus competent in the contemporary scenario. I extend my heartfelt gratitude to all the external members for their active participation.

I am also thankful to Dr. Bijoy V M (Associate Professor & Head, Department of Fisheries & Aquaculture, St. Albert's College) and Dr. Krishnakumar K S (Assistant Professor & Deputy CoE, Department of Chemistry, St. Albert's College) for their contributions to the syllabus revision. Lastly, I would like to thank all my colleagues for all the efforts and hardwork done for the revision of the syllabus.

Programme Objectives and Outcomes

M.Sc. Botany Programme is a two-year post-graduate programme, which deals with basic and advanced study on plants. It is one of the multi-disciplinary fields with great demand in various fields of research and development. The programme envisages developing understanding and knowledge for applying into sectors like agriculture, horticulture, floriculture, biotechnology, genomics, forest and environment. The programme is divided across 4 semesters of 90 days each.

Assessment of Learning Outcomes

M.Sc. Degrees are designed for students who plan a career in science with an emphasis on plants, especially those intending to pursue an advanced degree Botany/ Life sciences.

Expected Student Learning Outcomes

Students who have completed their PG degree in Botany should be competent in the following areas:

- **Critical Thinking**: Take informed actions after identifying the assumptions that frame our thinking and actions, checking out the degree to which these assumptions are accurate and valid, and looking at our ideas and decisions (intellectual, organizational, and personal) from different perspectives.
- **Problem solving:** Solve problems from the Disciplines of concern using the Knowledge, skills and attitude acquired from humanities / science / mathematics Social Sciences etc.
- **Self-directed and Life-long Learning**: Acquire the ability to engage in independent and life-long learning in the broadest context socio-technological changes.
- **Global perspective:** Understand the economic and social and ecological connections that link the world's nations and people

Department of Botany Programme Assessment

Student feedback would be obtained in exit interviews and questionnaires concerning learning outcome objectives, faculty advising, teaching and relevancy of courses in the required curriculum.

Programme Specific Outcomes

- To have comprehensive knowledge of classical and modern arenas in plant sciences.
- Integrate the acquired knowledge and skills to solve problems, take appropriate decisions, with an innovative approach.
- Share social, environmental and ethical concerns with fellow citizens in areas of biodiversity conservation, environmental protection and management.
- Proficiency in concepts, tools and techniques that have a multidisciplinary dimension in teaching, research and entrepreneurial ventures.

REGULATIONS OF ST. ALBERT'S COLLEGE (AUTONOMOUS)

POST GRADUATE PROGRAMMES UNDER CREDIT SEMESTER SYSTEM, 2020

(SACA-PG-CSS 2020)

1. SHORT TITLE

1.1. These regulations shall be called SACA Regulations (2020) governing Post Graduate Programmes under Credit Semester System (SACA-PG-CSS 2020).

1.2. These Regulations shall come into force from the Academic Year 2020-2021 onwards.

2. Scope

2.1. The regulations provided herein shall apply to all Regular Post-graduate programmes (except M.B.A) conducted in the Institution, with effect from the academic year 2020-2021.

2.2. The provisions herein supersede all the existing regulations for the regular post-graduate programmes conducted in the Institution (except M.B.A and M.Sc. Space Science and Technology).

3. DEFINITIONS

3.1. 'Academic Council' means the Committee constituted by the Governing body under this regulation to monitor the running of the post-graduate programmes under the Credit Semester System (SACA-PG-CSS 2020).

3.2. 'Academic Week' is a unit of five working days in which distribution of work is organized from day one to day five, with five contact hours of one hour duration on each day. A sequence of minimum of 18 such academic weeks constitutes a semester.

3.3. 'Audit Course' is a course for which no credits are awarded.

3.4. 'CE' means Continuous Evaluation (Internal Evaluation)

3.5. 'Comprehensive viva-voice' means the oral examinations conducted by the appointed examiners and shall cover all courses of study undergone by a student for the programme.

3.6. 'Core Course' means a course which cannot be substituted by any other course.

3.7. 'Course' means a course segment of subject matter to be covered in a semester. Each course is to be designed variously under lectures/ tutorials/ laboratory or fieldwork/ seminar/ project/ practical training/ assignments/ viva-voice etc., to meet effective teaching and learning needs.

3.8. 'Course Code' means a unique alphanumeric code assigned to each course of a programme.

3.9. 'Course Credit' on credit of a course is defined as a minimum of 1 hour lecture /minimum of two hours lab field work per week for 18 weeks in a Semester. The course will be considered as completed only by conducting the final examination.

3.10. 'Course Teacher' means the teacher of the institution in charge of the course offered in the programme.

3.11. 'Credit (Cr)' of a course is a numerical value which depicts the measure of the weekly unit of work assigned for that course in a semester

3.12. 'Credit point (CP)' of a course is the value obtained by multiplying the Grade Point (GP) by the credit (Cr) of the course CP = GP x Cr.

3.13. 'Cumulative Grade point average (CGPA)' is the value obtained by dividing the sum of credit points of all the courses taken by the students for the entire programme by the total number of credits and shall be rounded off to two decimal places. CGPA determines the overall performance of a student at the end of the programme. (CGPA = total CP obtained /Total credits of the programme)

3.14. 'Department' means any teaching Department in the Institution offering a programme of study approved as per the Act/ statutes of the University.

3.15. 'Department Council' means the body of all teachers of a Department in a college.

3.16. 'Dissertation' means a long document on a particular subject in connection with the project/ research/ field work etc.

3.17. 'Duration of a Programme' means the period of time required for the conduct of the programme. The duration of the post-graduate programme shall be 4 semesters spread over two academic years.

3.18. 'Elective course' means a course, which can be substituted, by an equivalent course from the same subject.

3.19. 'Elective Group' means a group consisting of elective courses for the programme.

3.20. 'ESE' means End Semester Evaluation (External Evaluation).

3.21. 'Evaluation 'is the process by which the knowledge acquired by the student is quantified as per the criteria detail in these regulations.

3.22. 'External Examiner 'is the teacher appointed from other colleges for the valuation of courses of study undergone by the students in a college. The external examiner shall be appointed by the College.

3.23. 'Exam Coordinator' is a teacher nominated by the Department Council to coordinate the continuous evaluation and other academic activities undertaken in the Department of the college.

3.24. 'Grace Grade Points' means grade points awarded to course(s), in recognition of the students' meritorious achievement in NSS/Sports/ Arts and cultural activities etc.

3.25. 'Grade point (GP) letter grade is assigned a 'Grade point' (GP) which is an integer indicating the numerical equivalent of the board level of performance of a student in a course.

3.26. 'Grade Point Average (GP)'is an index of the performance of student in a course. It is obtained by dividing the sum of the weighted grade points obtained in the course by the sum of the weights of the course. (GPA= ∑WGP/∑W).

3.27. 'Improvement course' is a course registered by a student for improving his/ her performance in that particular course.

3.28. 'Internal Examiner' is a teacher nominated by the department concerned to conduct internal evaluation.

3.29. 'Letter Grade' or 'Grade' for a course is a letter symbol (A^+, A, B^+, B, C, C^+, D) which indicates the broad level of performance of a student for a course.

3.30. 'SACA-PG-CSS 2020' means St. Albert's College Autonomous Regulations Governing Post Graduate Programmes under Credit Semester System, 2020.

3.31. 'Parent Department' means the Department which offers a particular post graduate programme.

3.32. 'Plagiarism' is the unreferenced use of other authors'' material in dissertations and assignments and is a serious academic offence.

3.33. 'Programme' means the entire course of study and examinations.

3.34. 'Project' is a core course in a programme. It means a regular project work with stated credits on which the student undergoes a project under the supervision of a teacher in the parent department/ any appropriate research center in order to submit a dissertation on the project work as specified. It allows students to work more autonomously to construct their own learning and culminate in a realistic, student-generated product for findings.

3.35. 'Repeat course' is a course that is repeated by the student for having failed in that course in an earlier registration.

3.36. 'Semester' means a team consisting of a minimum of 90 working days, inclusive of examinations, distributed over a minimum of 18 weeks of 5 working days each.

3.37. 'Seminar' means a lecture given by the student on a selected topic and is expected to train the student in self-study, collection of relevant matter from various resources, editing, document writing and presentation.

3.38. 'Semester Grade Point Average'(SGPA) is the value of trained by dividing the sum of credit points CP obtained by a student in the various courses taken in a semester by the

total number of credits for the course in that semester. The SGPA shall be rounded off to two decimal places. SGPA determines the overall performance of a student at the end of the semester (SGPA= Total CP obtained in the semester /Total Credits for the semester).

3.39. 'Tutorial' means a class to provide an opportunity to interact with students at their individual level to identify the strength and weakness of individual students.

3.40. 'University' means Mahatma Gandhi University, Kottayam, Kerala.

3.41. 'College' means St. Albert's College (Autonomous), Ernakulam, Kerala.

3.42. 'Weight' is a numeric measure assigned to the assessment units of various components of a course of study.

3.43. 'Weighted Grade Point' (WGP) is the grade point multiplied by weight. (WPG = GP x W).

3.44. 'Weighted Grade Point Average (WGPA)' is an index of the performance of a student in a course. It is obtained by dividing the sum of the weighted grade points by the sum of the weights. WGPA shall be obtained for CE (Continuous Evaluation) and ESE (End Semester Evaluation) separately and then the combined WGPA shall be obtained for each course.

3.45. Words and expressions used and not defined in this regulation but defined in the Mahatma Gandhi University Act and Statutes that you shall have the meaning assigned to them in the Act and Statute.

4. ACADEMIC COUNCIL: COMPOSITON OF ACADEMIC COUNCIL

1. The Principal (Chairman)
2. All Heads of the Departments
3. Four teachers of the college representing different categories of teaching staff by rotation on the basis of seniority of service in the college.
4. Not less than four experts/academicians from outside the college representing areas such as Industry, Commerce, Law, Education, Medicine, Engineering, Sciences etc., to be nominated by the Governing Body.
5. Three nominees of the university not less than Professors.
6. A faculty member nominated by the Principal (Member Secretary).

5. PROGRAMME STRUCTURE

5.1. The medium of instruction shall be English except for programmes under Faculty of Language and Literature.

5.2. Student shall be admitted to post graduate programmes under various faculties. The programme shall include three types of courses, Core courses, Elective courses and

Common core courses. There shall be a project with the dissertation and comprehensive viva-voce as core courses for all programmes. The programme shall also include assignments/ seminars/practicals project field study, etc.

5.3. **Elective course and Groups**

5.3.1. There shall be at least two and not more than four elective groups (Group A, Group B, Group C, etc.) comprising of three courses each for a programme and these elective courses shall be included either in the fourth semester or be distributed among third and fourth semesters. This clause is not applicable to MSW, MBA and M. Voc.

5.3.2. The number of elective courses assigned for study in a particular semester shall be the same across all elective groups for the programme concerned.

5.3.3. The colleges shall select any one of the elective groups for each programme as per the interest of the students, availability of faculty and academic infrastructure in the Institution.

5.3.4. The selection of courses from different elective groups is not permitted.

5.3.5. The elective group selected by the college shall be intimated to the Controller of Examinations without within two weeks of commencement of the semester in which the elective courses are offered. The elective group selected by the college for the students who are admitted in a particular academic year shall not be changed.

5.4. **Project work**

5.4.1. Project work shall be completed in accordance with the guidelines given in the curriculum and shall be carried out under the supervision of a teacher of the department concerned. A candidate may, however, in certain cases be permitted to work on the project in an Industrial/ Research Organization on the recommendation of the supervising teacher.

5.4.2. There shall be internal assessment and external assessment for the project work.

5.4.3. The project work shall be evaluated based on the presentation of the project work done by the student, the dissertation submitted and the Viva-voce on the project.

5.4.4. The external evaluation of the project work shall be conducted by an external examiner from different college and an internal examiner from the college concerned.

5.4.5. The final Grade of the project (External) shall be calculated by taking the average of the Weighted Grade Points given by the two external examiners and the internal examiner.

5.5. **Assignments:** Every student should submit at least one assignment as an internal component for each course.

5.6. **Seminar Lecture:** Each student shall deliver one seminar lecture as an internal component for every course with a weightage of two. The seminar lecture is expected to train the

student is self-study, collection of relevant matter from the various resources, editing, document writing, and presentation.

5.7. **Test Papers (Internal):** Student shall undergo at least two class tests as an internal component for each course with a weightage of one each. The best two shall be taken for awarding the grade for class tests.

5.8. No course shall have more than 5 credits unless otherwise specified.

5.9. **Comprehensive Viva-Voce**: Comprehensive Viva-voce conducted at the end of fourth semester of the programme and its evaluation shall be conducted by the examiners of the project evaluation.

5.9.1. Comprehensive Viva-Voce cover questions from all courses in the programme.

5.9.2. There shall be an internal assessment and an external assessment for the comprehensive Viva-voce.

6. ATTENDANCE

6.1. The minimum requirement of aggregate attendance during a semester for operating at the end-semester examination shall be 75%. Condonation of shortage of attendance for students having a minimum of 65% attendance, (upto a maximum of 10 days) in a semester subject to a maximum of two times during the whole Period of the programme may be granted by the College.

6.2. If a student represents his/her institution, University, State or Nation in Sports or Cultural or any other officially sponsored activities such as College Union/ University Union etc. he/ she shall be eligible to claim the attendance for the actual number of days participated subject to a maximum of 10 days in a semester based on the specific recommendations of the teacher concerned, class tutor, Head of the Department forwarded through the Dean Students Affairs subjected to the approval of the Principal. For exceptional achievements/situations, the Principal may recommend for the award of additional attendance to the Governing Body.

6.3. Those who could not register for the examination of a particular semester due to shortage of attendance will not be able to repeat the semester and will be removed from the rolls.

7. REGISTRATION/DURATION

7.1. A student shall be permitted to register for the programme at the time of admission.

7.2. A student who has registered for the programme shall complete the programme within a period of four years from the date of commencement of the programme.

8. ADMISSION

8.1. The admission to all regular PG programme shall be through the Centralised Allotment Process of the College.

8.2. If there is an entrance examination specified for the admission for a particular programme, it will be as per the directions of the office of the CoE of the college.

8.3. The eligibility criteria for admission to PG programmes shall be published by the College in the prospectus.

9. ADMISSION REQUIREMENTS

9.1. Candidates for admission to the first semester of the PG programme through CSS shall be required to have passed an appropriate Degree Examination of any recognized university/institutions. Other eligibility requirements for specific programmes will be published in the prospectus.

9.2. Students admitted under this programme are governed by the Regulations of the College.

10. PROMOTION

10.1. A student who registers for a particular semester examination shall be promoted to the next semester.

11. EXAMINATIONS

11.1. There shall be an examination conducted by St. Albert's College, (Autonomous) at the end of each semester.

11.2. Practical Examination shall be conducted by the College at the end of semester or at the end of even semester as prescribed in the syllabus of the particular programme. The number of examiners for the Practical Examination shall be prescribed by the Board of Studies of the program.

11.3. End Semester Examinations: The examinations shall normally be conducted at the end of each semester.

11.4. There shall be one End-semester examination of 3 hours duration for each lecture based courses.

11.5. A question paper may contain short answer type/annotation, short essay type questions problem and long essay type questions. Different types of questions shall have different weightages.

12. EVALUATION AND GRADING

12.1. **Evaluation:** The evaluation scheme for each course shall contain two parts; (a) End Semester Evaluation (ESE) (External Evaluation) and (b) Continuous Evaluation (CE) (Internal Evaluation). The ratio of weightage between internal and external is 1:3 (unless for the courses, it is otherwise specified by the BoS). Both End Semester Evaluation (ESE) and Continuous Evaluation (CE) shall be carried out using direct grading system.

12.2. Direct grading: The direct grading for CE (Internal) and ESE (External Evaluation) shall be based on 6 letter grades (A+, A, B, C, D and E) with numerical values of 5, 4, 3, 2, 1 and 0 respectively.

12.3. Grade Point Average GPA: internal and external components are separately graded and the combined grade point with weightage 1 for internal and 3 for external shall be applied to calculate the Grade Point Average (GPA) of each course. Letter grade shall be assigned to each course based on the categorization provided.

12.4. Internal evaluation for regular programme:The internal evaluation shall be based on a predetermined transparent system involving periodic written tests, assignments, seminars, lab skills, records, Viva-voce etc.

12.5. Components of internal (CE) and external evaluation (ESE): Grades shall be given to the evaluation of theory/ practical/ project/ comprehensive Viva-voce and all internal evaluations based on the Direct Grading System.

Proper guidelines shall be prepared by the BOS for evaluating the assignment, seminar, practical, project and the comprehensive viva-voce within the framework of the regulation.

12.6. There shall be no separate minimum grade point for internal evaluation.

12.7. The model of the components and its weightages of continuous evaluation (CE) and End Semester Evaluation (ESE) are as shown below:

a) For theory (CE) (Internal)

	Components	Weightage
i.	Assignment	2
ii.	Seminar	4
iii.	Best Two Test papers	4 (2 each)
Total		**10**

(Grades of best two test papers shall be considered. For test papers all questions shall be set in such a way that the answers can be awarded A+, A, B, C, D, E grade.)

b) For the theory (ESE) (External)

Evaluation is based on the pattern of questions specified 12.16.5

c) For Practical (CE) (Internal)

Components	Weightage
Written/Lab test	2
Lab involvement and Record	1
Viva	2
Total	**5**

(The components and the weightage of the components of the practical (Internal) can be modified by the concerned BOS without changing the total weightage 5.)

d) For Practical (ESE) (External)

Components	Weightage
Written / Lab test	13
Record	2
Total	**15**

[The components and the weightage of the practical (External) can be modified by the concerned BOS without changing the total weightage 15.]

e) For Project (CE) (Internal)

Components	Weightage
Relevance of the topic and analysis	2
Project content and presentation	2
Project viva	1
Total	**5**

(The Components and the weightage of the components of the project (Internal) can be modified by the concerned BOS without changing the total weightage 5.)

f) For Project (ESE) (External)

Components	Weightage
Relevance of the topic and analysis	3
Project content and presentation	7
Project viva	5
Total	**15**

(The Components and the weightage of the components of the project (External) can be modified by the concerned BOS without changing the total weightage 15.)

g) Comprehensive viva-voce (CE)(internal)

Components	Weightage
Comprehensive viva-voce (all courses from first semester to fourth semester)	5
Total	5

(Weightage of the components of the comprehensive viva-voce (internal) shall not be modified.)

h) Comprehensive viva-voce (CE)(External)

Components	Weightage
Comprehensive viva- voce (all courses from first semester to fourth semester)	15
Total	**15**

(Weightage of the components of the comprehensive viva-voce(external) shall not be modified unless specified by the respective BoS for a particular course.)

12.8. All grade point averages shall be rounded to two decimal points.

12.9. 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 the external examination.

12.10. There shall not be any chance for improvement for internal grade.

12.11. The course teacher and the Exam coordinator shall maintain the academic details of each student registered for the course and a copy should be kept in the department for verification for at least five years after the student completes the programme.

12.12. **External evaluation:** The external examination in theory courses is to be conducted by the College at the end of the semester. The answers should be in English expect those for the Faculty of Languages. The evaluation of the answer scripts shall be done by examiners based on a well-defined scheme of valuation. The external evaluation shall be done immediately after the examination.

12.13. Photocopies of the answer scripts of the external examination shall be made available to the students on request as per the rules prevailing in the College.

12.14. The question paper should be strictly on the basis of model question papers set and the directions prescribed by the BOS/Governing Body of the college for each programme.

12.15. **Pattern of questions**

12.15.1. Questions shall be set to access the knowledge acquired, standard application of Knowledge, application of knowledge in new situations, critical evaluation of knowledge and the ability to synthesize knowledge. Due weightages shall be given to each module based on content/ teaching hours allotted to each module.

12.15.2. The question setter shall ensure that questions covering all outcomes are met.

12.15.3. A question paper shall be a judicious mix of short answer type, short essay type/ problem solving type and long essay type questions.

12.15.4. The questions shall be prepared in such a way that the answers can be awarded A+, A, B, C, D, E grades.

12.15.5. Weight: Different types of questions shall be given different weights to quantify their range as follows:

Sl. No.	Type of Questions	Weight	Number of questions to be answered
1.	Short Answer type questions	1	8 out of 10
2	Short essay/ problem solving type questions	2	6 out of 8
3.	Long Essay type questions	5	2 out of 4

12.16. **Pattern of questions for practical**: the pattern of questions for external evaluation of practical shall be prescribed by the Board of Studies.

12.17. **Direct grading System:** Direct Grading System based on a 6-point scale is used to evaluate the Internal and External examinations taken by the students for various courses of study.

Grade	Grade Points
A+	5
A	4
B	3
C	2
D	1
E	0

12.18. **Performance Grading**

Students are graded based on their performance (GPA/SGPA/CGPA) at the examination on a 7-point scale as detailed below. *(7-point scale needed clarification)*

Range	Grade	Indicator
4.50 to 5.00	A+	Outstanding
4.00 to 4.49	A	Excellent

3.50 to 3.99	B+	Very good
3.00 to 3.49	B	Good(Average)
2.50 to 2.99	C+	Fair
2.00 to 2.49	C	Marginal(pass)
up to 1.99	D	Deficient(Fail)

12.19. No separate minimum is required for internal evaluation for a pass, but a minimum C grade is required for a pass in an external evaluation. However, a minimum C grade is required for pass in a course.

12.20. A student who fails to secure a minimum grade for a pass in a course will be permitted to write the examination along with the next batch.

12.21. **Improvement of course:** The candidates who wish to improve the grade/ grade point of the external examination of a course/ courses he/she has passed can do the same by appearing in the external examination of the semester concerned along with the immediate junior batch. This facility is restricted to first and second semesters of the program.

12.22. Semester Grade Point Average (SGPA) and Cumulative Grade Point Average (CGPA) calculations. The **SGPA** is the ratio of the sum of the credit points of all courses taken by a student in the semester to the total credit for that semester. After the successful completion of a semester, Semester Grade Point Average (SGPA) of a student in that semester is calculated using the formula given below.

Semester Grade Point Average –SGPA (S_j) = $\sum(C_i \times G_i) / \sum C_i$

(SGPA = Total credit Points awarded in all semesters / Total credits of the semester)

Where 'S_j' is the j^{th} semester, 'G_i' is the grade point scored by the student in the i^{th}course 'C_i' is the credit of i^{th} course.

12.23. Cumulative Grade Point Average (CGPA) of a programme is calculated using the formula:-

Cumulative Grade Point Average (CGPA) =$\sum(C_i x S_i) / \sum C_i$

(CGPA = Total credit Points awarded in a semester / Total credits of the programme)

Where '$\mathbf{C_i}$' is the credits for the $\mathbf{i}^{th}$ semester '$\mathbf{S_i}$' is the **SGPA** for the $\mathbf{i}^{th}$ semester. The **SGPA** and **CGPA** shall be rounded off to 2 decimal points.

For the successful completion of semester, a student shall pass all courses and score a minimum SGPA of 2.0 . However, a student is permitted to move to the next semester irrespective of her/ his **SGPA**.

13. GRADE CARD

13.1. The College under its seal shall issue to the students, a consolidated grade card on completion of the programme, which shall contain the following information.

a) Name of College
b) Name of the University
c) Title of the PG Program
d) Name of the Semesters
e) Name and Register Number of the student
f) Code, Title, Credits and Max GPA (Internal, External & Total) of each course (theory & Practical), project, viva etc., in each semester.
g) Internal, external and total grade, Grade Point (G), Letter Grade and Credit point (P) in each course opted in the semester.
h) The total credits and total credit points in each semester
i) Semester Grade Point Average (SGPA) and corresponding Grade in each semester
j) Cumulative Grade Point Average (CGPA), Grade for the entire Program.
k) Separate Grade card will be issued at the request of candidates and based on College Guidelines issued from time to time.
l) Details of description of evaluation process-Grade and Grade Point as well as indicators, calculation methodology of SGPA and CGPA as well as conversion scale shall be shown on the reverse side of the grade card.

14. AWARD OF DEGREE

The successful completion of all the courses with 'C' grade within the stipulated period shall be the minimum requirement for the award of the degree.

15. MONITORING COMMITTEE

There shall be a Monitoring Committee constructed by the Principal to monitor the internal evaluation conducted by departments.

16. POSITION CERTIFICATE

The College shall publish the list of top 3 candidates for each programme after the publication of the programme results. Position certificate shall be issued to candidates on their request.

Candidates shall be ranked in the order of merit based on the CGPA secured by them. Grace grade points awarded to the students shall not be counted for fixing that rank/position. Position certificates shall be signed by the Controller of Examinations.

17. GRIEVANCE REDRESSAL COMMITTEE

In order to address the grievance of students a three-level Grievance Redressal mechanism is envisaged. A student can approach the upper level only if grievance is not addressed at the lower level.

17.1. **Class Level:** The cell is chaired by the class tutor and the course teacher or a teacher nominated by the Head of the Department.

17.2. **Department level**: The College shall form a Grievance Redressal Committee in each department comprising of the course teacher and one senior teacher as members and the Head of the Department as Chairperson. The committee shall address all grievances relating to the internal assessment grade of the students.

17.3. **College level:** A committee with the Principal as Chairman, Dept. Coordinator, HOD of concerned Department and a senior teacher nominated by the Executive Committee as members.

18. TRANSITORY PROVISION

Notwithstanding anything contained in these regulations, the Governing Body shall, for a period of two years from the date of coming into force of these regulations, have the power to provide by order that these regulations shall be applied to any programme with such modifications as may be necessary.

19. Credits allotted for program and Courses

19.1. Total credit for each program shall be 80 except MSW, M.Voc. and MBA programs.

19.2. Semester-wise total credit can vary from 16 to 25.

19.3. The minimum credit of a course is 2 and maximum credit is 5 except for M.Voc., MBA and MSW.

20. Course code: The course codes assigned for all courses (core courses, elective courses, common courses etc.) shall be unique.

21. Models of distribution of courses, course codes, type of the course, credits, teaching hours for a program are given in the following table.

Example **Programs with the practical-Total Credits 80-** scheme of the syllabus

Semester	Course Code	Course name	Type of the course	Teaching Hours Per Week	Credit	Total Credits
I	Course.code1	Name1	Core	4	4	19
	Course.code2	Name2	Core	4	4	
	Course.code3	Name3	Core	4	4	
	Course.code4	Name4	Core	3	3	
	Practical Course.code5	Name5	Core	10	4	
II	Course.code6	Name6	Core	4	4	19
	Course.code7	Name7	Core	4	4	
	Course.code8	Name8	Core	4	4	
	Course.code9	Name9	Core	3	3	
	Practical-Course.code10	Name10	Core	10	4	
III	Course.code11	Name11	Core	4	4	19
	Course.code12	Name12	Core	4	4	
	Course.code13	Name13	Core	4	4	
	Course.code14	Name14	Core	3	3	
	Practical Course.code15	Name15	Core	10	4	
IV	Course.code16	Name16	Elective	5	4	23
	Course.code17	Name17	Elective	5	4	
	Course.code18	Name18	Elective	5	4	
	Practical-Course.code19	Name19	Core	10	4	
	Project-Course.code20	Name20	Core		4	
	Comprehensive viva-voce - Course.code 21	Name 21	Core		3	
	Total					**80**

Appendix

1. **Evaluation first stage- Both internal and external (to be done by the teacher)**

Grade	Grade Points
A+	5
A	4
B	3
C	2
D	1
E	0

The final Grade range for courses SGPA and CGPA

Range	Grade	Indicator
4.50 to 5.00	A+	Outstanding
4.00 to 4.49	A	Excellent
3.50 to 3.99	B+	Very good
3.00 to 3.49	B	Good
2.50 to 2.99	C+	Fair
2.00 to 2.49	C	Marginal
Upto 1.99	D	Deficient(Fail)

Theory -External – ESE

Maximum weight for external evaluation is 30. Therefore, Maximum Weighted Grade Point (WGP) is 150

Type of Question	Qn. No's	Grade Awarded	Grade point	Weights	Weighted Grade Point
Short Answer	1	A+	5	1	5
	2	-	-	-	-
	3	A	4	1	4
	4	C	2	1	2
	5	A	4	1	4
	6	A	4	1	4
	7	B	3	1	3
	8	A	4	1	4
	9	B	3	1	3
	10	-	-	-	
Short Essay	11	B	3	2	6
	12	A+	5	2	10
	13	A	4	2	8
	14	A+	5	2	10
	15	-	-	-	-
	16	-	-	-	-
	17	A	4	2	8
	18	B	3	2	6
Long Essay	20	A+	5	5	25
	21	-	-	-	-
	22	-	-	-	-
	23	B	3	5	15
			TOTAL	**30**	**117**

Calculation:

Overall Grade of the theory paper = Sum of Weighted Grade Points /Total weight 117/30 = 3.90 = Grade B

Theory- Internal-CE

Maximum weight for internal evaluation is 10. Therefore, Maximum Weighted Grade Point (WGP) is 50.

Components	Weight (W)	Grade Awarded	Grade Point(GP)	WGP= W *GP	Overall Grade of the course
Assignment	2	A	4	8	**WGP/Total weight = 48/10 =4.8**
Seminar	4	A+	5	20	
Test paper 1	2	A+	5	10	
Test paper 2	2	A+	5	10	
Total	**10**			**48**	**A+**

Practical-External-ESE

Maximum weight for external evaluation is 5. Therefore Maximum Weighted Grade Point (WPG) is 75.

Components	Weight (W)	Grade Awarded	Grade Point(GP)	WGP= W*GP	Overall Grade of the course
Written/Lab	7	A	4	28	
Test					**WGP/Total**
Lab					**Weight**
Involvement &Record	3	A+	5	15	**= 58 / 15 = 3.86**
Viva	5	B	3	15	
Total	**15**			**58**	**B**

Practical-Internal-CE

Maximum weight for internal evaluation is 5. Therefore, Maximum Weighted Grade Point (WGP) is 25

Components	Weight (W)	Grade Awarded	Grade Point(GP)	WGP=W*GP	Overall Grade of the course
Written/ Lab test	2	A	4	8	**WGP/Total weight =17/5=3.40**
Lab involvement & record	1	A+	5	5	
Viva	2	C	2	4	
Total	**5**			**17**	**B**

Project-External-ESE

Maximum weight for external evaluation is 15. Therefore, Maximum weighted Grade Point (WGP) is 75.

Components	Weight (W)	Grade Awarded	Grade Point(GP)	WGP= W*GP	Overall Grade of the course
Relevance of the topic & Analysis	2	C	2	4	**WGP/Total weight = 59/15= 3.93**
Project content & presentation	8	A+	5	40	
Project viva-voce	5	B	3	15	
Total	**15**			**59**	**B**

Project-Internal-CE

Maximum weight for Internal evaluation is 5. Therefore, Maximum Weighted Grade Point (WGP) is 25.

Components	Weight (W)	Grade Awarded	Grade Point(GP)	WGP= W *GP	Overall Grade of the course
Relevance of the topic & Analysis	2	B	3	6	**WGP/Total weight = 21/5 = 4.2**
Project content &presentation	2	A+	5	10	
Project viva-voce	1	A+	5	5	
Total	**5**			**21**	**A**

Comprehensive viva-voce-External-ESE

Maximum weight for External evaluation is 15. Therefore, maximum Weighted Grade Point (WGP) 75.

Components	Weight (W)	Grade Awarded	Grade Point(GP)	WGP=W* GP	Overall Grade of the course
Comprehensive viva-voce	15	A	4	60	**WGP/Total weight = 60 / 15 = 4**
Total	**15**			**60**	**A**

Comprehensive viva-Internal-CE

Maximum Weight for Internal evaluation is 5. Therefore, Maximum Weighted Grade Point (WGP) is 25.

Components	Weight (W)	Grade Awarded	Grade Point(GP)	WGP= W *GP	Overall Grade of the course
Comprehensive viva-voce	5	A+	5	25	**WGP/Total weight = 25/ 5 = 5**
Total	**5**			**25**	**A+**

Evaluation- Second stage (to be done by the College)

Consolidation of the Grade (GPA) of a Course PC-1

The End Semester Evaluation valuation (ESE) (External evaluation) grade awarded for the course PC -1 is A and its Continuous Evaluation (CE) (Internal Evaluation) grade is A. The consolidated grade for the course PC -1 is as follows:

Evaluation	Weight	Grade awarded	Grade Points awarded	Weighted Grade Point
External	3	A	4.20	12.6
Internal	1	A	4.40	4.40
Total	**4**			**17**
Grade of a course.	GPA of the course =Total weighted Grade Points/Total weight **17/4 =4.25 = Grade A**			

Evaluation- Third stage (to be done by the College)

Semester Grade Point Average (SGPA)

Course code	Title of the course	Credits (C)	Grade Awarded	Grade Points (G)	Credit Points(CP=C X G)
01	**PC-1**	**5**	**A**	**4.25**	**21.25**
02	**-----**	**5**	**A**	**4.00**	**20.00**
03	**-----**	**5**	**B+**	**3.80**	**19.00**
04	**-----**	**2**	**A**	**4.40**	**8.80**
05	**-----**	**3**	**A**	**4.00**	**12.00**
TOTAL		**20**			**81.05**
SGPA	**Total credit points / Total credits = 81.05/20 = 4.05= Grade- A**				

Evaluation-Fourth Stage (to be done by the College)

Cumulative Grade Point Average (CGPA)

If a candidate is awarded three **A+** grades in semester 1 (**SGPA** of semester 1), semester 2 (**SGPA** of semester 2) and semester 4 (**SGPA** of semester 4) and a **B** grade in semester 3 (**SGPA** of semester 3). Then the **CGPA** is calculated as follows:

Semester	Credit of the Semesters	Grade Awarded	Grade point (SGPA)	Credit points
I	20	A+	4.50	90
II	20	A+	4.60	92
III	20	B	3.00	60
IV	20	A+	4.50	90
TOTAL	**80**			**332**
CGPA= Total credit points awarded / Total credit of all semesters = 332 / 80 = 4.15 **(Which is in between 4.00 and 4.49 in 7-point scale). Therefore, the overall Grade awarded in the program is A**				

Programme Structure

Semester I

Course Code	Course Title	Teaching Hours		Credits
		Theory	Practical	
PBT1CRT0122	Microbiology	27	9	4
	Phycology	45	36	
PBT1CRT0222	Mycology	36	36	4
	Crop Pathology	36	18	
PBT1CRT0322	Bryophytes	36	18	4
	Pteridophytes	36	36	
PBT1CRT0422	Gymnosperms Paleobotany	36	27	3
	Evolution	18	--	
PBT1CRP0122	Microbiology, Phycology, Mycology and Crop Pathology Practical			2
PBT1CRP0222	Bryology, Pteridology, Gymnosperms, and Paleobotany Practical			2
Total		**270**	**180**	**19**

Semester II

Course Code	Course Title	Teaching Hours		Credits
		Theory	Practical	
PBT2CRT0122	Anatomy	36	27	4
	Developmental Biology	18	9	
	Horticulture	18	9	
PBT2CRT0222	Cell Biology	27	18	4
	Genetics	27	18	
	Plant Breeding	18	9	
PBT2CRT0322	Plant Physiology	45	36	4
	Biochemistry	27	27	
PBT2CRT0422	Molecular Biology	54	18	3
PBT2CRP0122	Anatomy, Developmental Biology, Horticulture, Cell Biology, Genetics and Plant breeding Practical			2
PBT2CRP0222	Plant Physiology, Biochemistry and Molecular Biology Practical			2
Total		**270**	**180**	**19**

Semester III

Course Code	Course Title	Teaching Hours		Credits
		Theory	Practical	
PBT3CRT0122	Research Methodology	18	9	4
	Phytochemistry	18	27	
	Biostatistics	18	9	
	Biological Techniques	18	18	
PBT3CRT0222	Biotechnology, Bioinformatics and Bio-nanotechnology	72	36	4
PBT3CRT0322	Angiosperm Taxonomy, Economic Botany and Ethnobotany	72	63	4
PBT3CRT0422	Environmental Science	54	18	3
PBT3CRP0122	Research Methodology, Phytochemistry, Biostatistics, Biological Techniques			2
	Biotechnology, Bioinformatics and Bionanotechnology Practical			
PBT3CRP0222	Angiosperm Taxonomy, Economic Botany, Ethnobotany and Environmental Science Practical			2
Total		**270**	**180**	19

Semester IV

Course Code	Course Title	Teaching Hours		Credits
		Theory	Practical	
PBT4CRT0122	Elective course I Biotechnology - Plant tissue Culture and Microbial Biotechnology	90	72	4
PBT4CRT0222	Elective course I Biotechnology – Genetic Engineering, Genomics and Immunology	90	54	4
PBT4CRT0322	Elective course I Biotechnology – Genomics, Transcriptomics, Proteomics and Bioinformatics	90	54	4
PBT4CRP0122	Elective course I Biotechnology- Practical Paper I Plant Tissue Culture and Microbial Biotechnology			2
PBT4CRP0222	Elective course I Biotechnology- Practical Paper II Genetic Engineering, Genome Editing, Immunology, Genomics, Transcriptomics, Proteomics and Bioinformatics			2
PBT4CRT0122	Elective course II Microbiology- Food, Agricultural and Environmental microbiology			4
PBT4CRT0222	Elective course II Microbiology- Clinical microbiology			4
PBT4CRT0322	Elective course II Microbiology- Industrial microbiology			4
PBT4CRP0122	Elective course II Microbiology- Practical Paper I Food, Agricultural and Environmental microbiology			2
PBT4CRP0222	Elective course II Microbiology- Practical Paper II Clinical microbiology and Industrial microbiology			2
PBT4CRT0122	Elective course III Environmental Science- Basic concepts in Environmental studies			4
PBT4CRT0222	Elective course III Environmental Science- Natural resources and their Management			4
PBT4CRT0322	Elective course III Environmental Science- Environmental monitoring and Management			4

PBT4CRP0122	Elective course III Environmental Science-Practical Paper I Basic concepts in Environmental studies			2
PBT4CRP0222	Elective course III Environmental Science-Practical Paper II Natural resources and their management & Environmental monitoring and Management			2
PBT4CPR0122	Project work			4
PBT4CRV0122	Viva-voce			3
Total		**270**	**180**	**23**

Detailed Syllabus: Semester I

Course code	Name of the Course
PBT1CRT0122	MICROBIOLOGY AND PHYCOLOGY
PBT1CRT0222	MYCOLOGY AND CROP PATHOLOGY
PBT1 CRT0322	BRYOLOGY AND PTERIDOLOGY
PBT1 CRT0422	GYMNOSPERMS, PALEOBOTANY AND EVOLUTION
PBT1CRP0122	MICROBIOLOGY, PHYCOLOGY, MYCOLOGY AND CROP PATHOLOGY- PRACTICAL
PBT1CRP0222	BRYOLOGY, PTERIDOLOGY, GYMNOSPERMS, AND PALEOBOTANY – PRACTICAL

Total Credits: 19

Total Hours: 450

Course-1: Microbiology & Phycology (PBT1CRT0122)

No. of Credits- 4

No. of Contact Hours: Theory 27+ 45= 72 Hours; Practicals 9+36=45 Hours)

Course Overview and Context:

This course is designed to enable the learner to understand the biodiversity of the lower life forms like microbes and algae. It deals with the basic aspects of microbiology and aims in studying the classification of microbes especially bacteria and viruses, their diversity and activity in their natural environment, plant microbe interactions, their mutual interactions, survival and adaptation strategies with special emphasis on pathogenic microbes. It also provides insight into the variation in the habitat and thallus organization of algae along with their ecological and economic importance.

Course objectives and outcomes:

- Describe the unique features of different groups of bacteria and virus.
- Apply the conventional and advanced techniques in isolation, culturing and identification of bacteria.
- Determine the classificatory approaches and principles in algal taxonomies.
- Examine the morphology, internal structure and reproduction of different types of algae for better understanding and their identification and culturing.
- Evaluation of ecological and economic importance of algae and apply practical skills in culturing, identification and algal biotechnology.

PBT1CRT0122: Microbiology and Phycology

(Theory 27+45=72 Hours; Practical 9+36=45 Hours) Credits-4

Microbiology (27 Hours)

Module 1: Introduction to Microbiology (2 Hours)

Milestones in microbiology, Microbial taxonomy and phylogeny - Major groups and their characteristics (Five kingdom system and Three domain system of classification).

Module 2: Bacteria (7 Hours)

Bacterial morphology. Classification of Bacteria according to Bergey's manual of systematic bacteriology (Brief study up to family). Ultra structure of Gram positive and Gram negative bacteria; cell membrane, cell wall, flagella, pili, fimbriae, capsule and slime, ribosome and endospores. Major groups of Bacteria: Nanobes, VBNC, Spirochetes, Rickettsias, Chlamydias, Mycoplasmas, Actinomycetes, Myxobacteria. Antibiotics and their mode of action, bacterial resistance mechanisms, horizontal gene transfer, integrons.

Module 3: Bacterial systematics (4 Hours)

Systematic identification of bacteria: Phenotypic-Morphology, Motility, Colony characters, Biochemical tests (Tests for carbohydrates, proteins and enzymes). Molecular techniques for the identification of bacteria-16S rRNA sequencing. A brief account on metagenome analysis for the identification of non-culturable microbes.

Module 4: Culture of microorganisms (4 Hours)

Sterilization techniques in microbiology-physical and chemical methods (Physical-dry heat and moist heat, radiation, filter sterilization; Chemical-commonly used surface sterilant), Disinfection; Methods of isolation of pure cultures. Types of culture media. Enrichment culture techniques. Maintenance and preservation of pure cultures.

Module 5: Plant–Microbe interactions (2 Hours)

Brief study on endophytic bacteria, their role in plant growth promotion and secondary metabolite production.

Module 6: Viruses (8 Hours)

Nomenclature and classification-types of viruses-DNA and RNA Viruses, properties of viruses, morphology (symmetry) of viruses; Capsid and their arrangements; types of envelops and their composition, Viral genome. Viral replication: Lytic and Lysogenic cycles - Lytic cycle in T even phages, and lysogeny in lambda phage. Sub viral particles - prions, viroids, virusoids (brief description only).

Viral pathogens of humans and their management strategies with special reference to Nipah, SARS and Dengue.

Practical (9 Hours)

1. Biochemical tests – Indole, Methyl Red, Voges Proskauer, Citrate (IMViC), Urease and TSI
2. Preparation and sterilization of microbial culture media -Nutrient broth and nutrient agar
3. Isolation of microbes from soil: Serial dilution - pour plate/spread plate method.
4. Streak out a bacterial culture on an agar plate and isolation of colonies –Quadrant streaking method.
5. Antibacterial assay - disc diffusion/agar well method.

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Phycology (45 Hours)

Module 7: Introduction (4 Hours)

History of algal classification. Detailed study of the classification by F. E. Fritsch. Brief account on the classification (Upto groups and divisions) by Edward Lee (2008). Gene sequencing and algal systematics (Brief study only). Centers of algal research in India. Contributions of Indian phycologists – M O P Iyengar, GS Venkataraman, T V Desikachary.

Module 8: General features of Algae (27 Hours)

Habit, habitat and distribution of Algae. Major characteristics of Cyanophyceae, Chlorophyceae, Xanthophyceae, Bacillariophyceae, Dinophyceae, Phaeophyceae and Rhodophyceae. Range of thallus structure. Algal components: Cell wall, flagella, eye-spot, pigments, pyrenoid, photosynthetic products. Reproduction in algae: Vegetative, asexual and sexual reproduction (development of sex organs not necessary). Major patterns of life cycles in algae and post fertilization stages in Phaeophyceae and Rhodophyceae. Algae and fossil records, special reference to India; a short description on *Rafatazmia chitrakootensis.*

Module 9: Ecological and Economic importance of Algae (9 Hours)

Ecological importance of Algae. Primary productivity. Algae in symbiotic association, Ultraviolet radiation absorption by algae. Algae as food, fodder, biofertilizer, medicine, industrial uses and other useful. Algae in experimental studies. (SCP, Biofuel, Live feeds, EPS). Chemically mediated interactions in microalgae: Allelopathy (brief account only). Harmful effects of algae: Algal blooms, causative organisms, symptoms and toxins of major toxic algal blooms (Amnesic Shellfish Poisoning [ASP], Paralytic Shellfish Poisoning [PSP] and Cyanophycean toxins).

Module 10: Algal biotechnology (5 Hours)

Methods and techniques of collection, preservation and staining of Algae. Algal culture: Importance, methods; Algal culture media (Walne's medium)

Practical (36 Hours)

1. Critical study of diagnostic features and identification of the following genera based on morphological, anatomical and reproductive parts;

a) *Cyanophyceae - Gleotrichia, Spirulina, Microcystis, Oscillatoria, Lyngbya, Anabaena, Nostoc, Rivularia, Scytonema.*

b) *Chlorophyceae - Chlamydomonas, Volvox, Ulothrix, Microspora, Ulva, Cladophora, Pithophora. Coleochaete, Chaetophora, Drapernaldia, Trentepohlia, Fritschiella, Cephaleuros, Oedogonium, Bulbochaete, Zygnema, Mougeotia, Sirogonium, Bryopsis, Acetabularia, Codium, Caulerpa, Halimeda, Chara, Nitella.*

c) *Xanthophyceae – Vaucheria.*

d) *Bacillariophyceae –Odontella, Navicula.*

e) *Phaeophyceae - Ectocarpus, Colpomenia, Hydroclathrus, Dictyota, Padina, Sargassum, Turbinaria.*

f) *Rhodophyceae - Batrachospermum, Gelidium, Amphiroa, Gracilaria, Polysiphonia.*

2. Students are to collect and identify algae from different habitats. Prepare and submit a report of the field work with sufficient photographs of algal collection, OR, a visit to an algal research centre and submit a report.

3. Estimation of photosynthetic pigments in microalgae.

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Course-2: Mycology & Crop Pathology (PBT1CRT0222)

No. of Credits- 4

No. of Contact Hours: Theory 36+ 36= 72 Hours; Practicals 36+18=54Hours)

Course Overview and Context:

This course is designed to learn about the fascinating world of fungi, their biology, importance and impacts they have on humans and natural ecosystems. The modules of crop pathology deal with the biotic and abiotic agents responsible for disease development, their management strategies. Students will have a first-hand information on selected plant diseases, their causative agents like bacteria, viruses, fungi and nematodes. This course will help in designing future mycologists and research aptitude in mycological research.

Course objectives and outcomes:

- Analyse and evaluate the characteristic features, the principles involved in classification and economic and agricultural significance of fungi
- Examine the fungal interactions in nature and predict their adaptive strategies.
- Enrich skills in basic methods of mycological studies and gain hands-on experience on fungal culture, isolation and identification.
- Relate basic methods of mycological studies and hands-on experience on pathogen culture and isolation methods in identification of the same.
- Apply the principles in the biology of plant pathogens and pests including disease epidemiology and disease management.

PBT1CRT0222: MYCOLOGY AND CROP PATHOLOGY
(Theory 36 + 36 = 72 Hours; Practical 36 + 18 = 54 Hours) Credits 4

MYCOLOGY (36 Hours)

Module 1: General introduction (2 Hours)

General characters of Fungi and their significance. Major criteria followed for fungal classification. Principles of classification of fungi, Classifications by C J Alexopoulos and Mims (1979).

Module 2: Thallus structure and reproduction in Fungi (27 Hours)

Mycelial structure and reproduction of Myxomycota – Acrasiomycetes (Brief introduction only) Hydromyxomycetes, (Brief introduction only) Myxomycetes, Plasmodiophoromycetes. Mastigomycotina - Chytridiomycetes, (Brief introduction only) Hyphochytridiomycetes (Brief introduction only) Oomycetes. Zygomycotina - Zygomycetes, Trichomycetes. Ascomycotina - Hemiascomycetes, Pyrenomycetes, Plectomycetes, Discomycetes, Laboulbeniomycetes, Loculoascomycetes. Basidiomycotina - Teliomycetes, Hyphomycetes, Gastromycetes. Deuteromycotina - Blastomycetes, Hyphomycetes, Coelomycetes. Types of fruiting bodies in fungi.

Module 3: Fungal associations and Fungal Physiology (5 Hours)

Symbionts - Lichens, Mycorrhiza, Fungus-insect mutualism. Parasites - Common fungal parasites of plants, humans, insects and nematodes. Saprophytes - Fungal decomposition of organic matter, coprophilous fungi, cellulolytic fungi, lignolytic fungi. Agricultural significance of Fungi - Mycoparasite, mycoherbicide.

Module 4: Physiology of Fungi (2 Hours)

Fungal Metabolic pathways, Secondary metabolic pathways, Mycotoxins Aflatoxins, Amatoxin, Ergot, Fusarin (general account) Antibiotics (Brief introduction only)

Practical (36 Hours)

1. Critical study of the following types by preparing suitable micropreparations; Stemonitis, Phytophthora, Rhizopus, Aspergillus, Penicillium, Pilobolus, Peziza, Phyllochora,

Puccinia, Termitomyces, Pleurotus, Auricularia, Polyporus, Lycoperdon, Dictyophora, Geastrum, Cyathus, Fusarium, Alternaria, Pestalotia, Parmelia, Graphis , Usnea, Cladonia.

2. Isolation of fungi from soil and water by culture plate technique.
3. Staining and microscopic study of mycorrhizal colonization in root.
4. Collection and identification of common field macro fungi/lichen (10 types). Submit report with photographs.
5. Spore isolation and root staining, On farm mycorrhizal inoculums production techniques using nurse crops of typical genus isolated and its maintenance (brief study).
6. Students should undergo training in mushroom cultivation (Pleurotus/ Calocybe) cultivation using locally available growing medium and then grow mushrooms in their own house, prepare a report and submit it with photographs along with their practical exam for valuation.

References

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Publishes (India)

CROP PATHOLOGY (36 Hours)

Module 1: Introduction to crop pathology (2 Hours)

Classification of plant diseases based on; Major causal agents - biotic and abiotic, General symptoms.

Module 2: Process of infection and pathogenesis (4 Hours)

Penetration and entry of pathogen into host tissue – mechanical, physiological and enzymatic.

Host-parasite interaction, enzymes and toxins in pathogenesis.

Module3: Defence mechanism in plants (4 Hours)

Pre-existing structural and biochemical defence mechanisms, lack of essential nutrients. Induced structural and biochemical defence mechanisms, Inactivation of pathogen enzymes and toxins. Altered biosynthetic pathways. Phytoalexins.

Module 4: Transmission of plant disease (3 Hours)

Spread and transmission of plant diseases by wind, water, seeds and vectors.

Module 5: Plant disease management (8 Hours)

Exclusion, eradication and protection. Chemical means of disease control – common fungicides, antibiotics and nematicides. Biological means of disease control. Biotechnological approaches to disease resistance: Fungi in agricultural biotechnology, control of fungal plant pathogens by mycofungicides. Transgenic approaches to disease resistance.

Module 6: Major diseases in plants (15 Hours)

Cereals: Rice - blast disease, bacterial blight; Wheat - black stem rust disease. Vegetables: Chilly - leaf spot; Ladies finger - vein clearing disease. Fruits: Banana - bacterial leaf blight, Bunchy top; Mango - Anthracnose; Citrus - bacterial canker; Papaya – mosaic. Spices: Ginger - rhizome rot; Pepper - quick wilt; Cardamom - marble mosaic disease. Oil seeds: Coconut - grey leaf spot, bud rot disease. Rubber yielding: *Hevea braziliensis* - abnormal leaf fall, powdery mildew. Sugar

yielding: Sugarcane - red rot; root knot nematode. Cash crops: Arecanut –Mahali disease. Beverages: Tea - blister blight; Red rust; Coffee – leaf rust.

Practical **(18 Hours)**

1. Identify the diseases mentioned in the syllabus with due emphasis on symptoms and causative organisms by Herbarium/ live specimen.
2. Isolation of pathogens from diseased tissues (leaf, stem, fruit and seed) by blotter / culture methods.
3. Collection and preservation of specimens from infected plants. Submit 5 herbarium sheets/live specimens along with a report.
4. Culture media preparation and sterilization PDA/ Czapek dox's medium

References

- K S Bilgrami, H C Dube. A text book of modern plant pathology.
- Gareth Johnes. Plant pathology: principles and practice.
- R S Mehrotra. Plant Pathology.
- M N Kamat. Practical plant pathology.
- V K Gupta, T S Paul. Fungi and Plant disease.
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- Rangaswamy, A Mahadevan. Diseases of crop plants in India.
- B P Pandey. Plant Pathology.
- George N Agrios (2006). Plant pathology (V Edn). Elsevier Academic Press.

Course-3: Bryology & Pteridology (PBT1CRT0322)

No. of Credits- 4

No. of Contact Hours: Theory 36+ 36= 72 Hours; Practicals 18+36=54Hours)

Course Overview and Context:

This course is designed to enable the learner to familiarize the natural habitat and diversity of Bryophytes and Pteridophytes. The first four modules of this course deal with the general characters, thallus organization and classification of Bryophytes, their diversity, ecological and economic importance. The next five modules deal with the study of Pteridophytes, their habitats, life cycle, and their ecological and economic importance.

Course objectives and outcomes:

- Applies the knowledge obtained to identify the various Bryophytes and Pteridophytes.
- Differentiates between the life-cycles of homosporous and heterosporous Pteridophytes.
- Analyses how heterospory leads to seed habit in the higher plants.
- Realises the ecological and economic importance of Bryophytes and Pteridophytes and how they can be utilised in daily life.
- Recognizes the natural habitat, diversity, general features and classification of Bryophytes and Pteridophytes.

PBT1CRT0322: BRYOLOGY AND PTERIDOLOGY

(Theory 36 + 36 = 72 Hours; Practical 18 + 36= 54 Hours) Credits: 4

Module 1: Introduction (4 Hours)

Diversity in forms habit and habitat. Origin and evolution of bryophytes. Trends in classification of Bryophytes: traditional and modern systems of classification (Rothmaler1951, Goffinet *et al* 2008) Contributions of Indian bryologists (Shiv Ram Kashyap, SK Pande, SC Srivastava). Fossil bryophytes.

Module 2: Ecological significance of bryophytes (3 Hours)

Ecological significance of bryophytes with special reference on environmental monitoring. Water relations and regeneration techniques. Symbiotic associations of bryophytes.

Module 3: Economic importance of bryophytes (3 Hours)

Economic importance of bryophytes. Cultivation and conservation of bryophytes *with* special note on *In vitro* culture techniques of bryophytes (brief description only).

Module 4: General characters and thallus organization (26 Hours)

General characters and comparative account of sporophyte, gametophyte, their interrelationships, spore dispersal mechanisms of following orders with reference to the types mentioned in the practical (development of sex organs not necessary). Hepaticopsida (Sphaerocarpales, Marchantiales, Jungermanniales and Calobryales) Anthocerotopsida (Anthocerotales) Bryopsida (Sphagnales, Polytrichales and Bryales).

Practical (18 Hours)

1. Detailed study of the structure of gametophytes and sporophytes of the following genera of Bryophytes by suitable micropreparation: *Riccia, Targionia, Cyathodium, Marchantia, Lunularia, Dumortiera, Reboulia, Pallavicinia, Porella, Anthoceros, Notothylas, Sphagnum, Pogonatum.*
2. Students are expected to submit a report of field trip to natural habitats of bryophytes to familiarize with the diversity of bryophytes.

References

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- Campbell, Ditt (1940). *The evolution of land plants*. Stanford University Press.
- Srivastava S N (1992). *Bryophyta*. Pradeep Publications.

PTERIDOLOGY (36 Hours)

Module 1: General introduction (2 Hours)

Introduction, general characteristics and origin of Pteridophytes (Anthocerotean theory and algal origin)

Module 2: Classification and evolution of Pteridophytes (9 Hours)

Classification by Smith (1955), Zimmermann (1959) and a brief account of classification by Pteridophyte Phylogeny Group – PPG-2016 (up to order). Evolution: Telome theory, Stelar evolution in pteridophytes. Heterospory and seed habit in pteridophytes.

Module3: Structure of the plant body (20 Hours)

Distribution, habitat, morphology, anatomy of sporophytic and gametophytic generation and reproduction of the following classes with reference to the genera mentioned (development of sex organs is not necessary).

Division: Psilophyta

Class-Psilophytopsida

Order – Psilophytales-Rhynia

Class-Psilotopsida

Order – Psilotales-Psilotum

Division: Lycophyta

Class- Eligulopsida

Order Lycopodiales-Lycopodium

Class- Ligulopsida

Order-Selaginellales-Selaginella

Order – Isoetales-Isoetes

Order – Pleuromeiales-Pleuromeia

Order – Lepidodendrales-Lepidodendron, Lepidocarpon and Stigmaria

Division: Sphenophyta (Calamophyta)

Class- Sphenophyllopsida

Order – Sphenophyllales-Sphenophyllum

Class-Calamopsida

Order – Equisetales-Equisetum.

Division:Filicophyta

Class- Eusporangiopsida

Order –Ophioglossales-Ophioglossum

Order – Marattiales-Angiopteris

Class- Protoleptosporangiopsida

Order – Osmundales-Osmunda

Class- Leptosporangiopsida

Order – Filicales-Pteris, Adiantum, Gleichenia and Lygodium

Order– Marsileales-Marsilea

Order – Salviniales-Salvinia and Azolla.

Class- Primopteropsida

Order – Cladoxylales-Cladoxylon

Order –Coenopteridales

Module 4: Developmental studies in Pteridophytes (3 Hours)

Development of sporangium, mechanism of spore dispersal. Apogamy and apospory in pteridophytes.

Module 5: Ecological and economic importance (2 Hours)

Ecological significances: Diversity of macro and micro habitats of Pteridophytes in the major ecosystems. Ecological roles by pteridophytes: stabilization of disturbed habitats, prevention of soil and nutrient leaching, micro-habitats for seed/spore germination. Economic importance of pteridophytes: General- as garden plants, as food/food supplements, as medicine, as other useful items. Pollution control phytoremediation by ferns. Biofertilizer- *Azolla-Anabaena*- model.

Practical (36 Hours)

1. Study of morphology and anatomy of vegetative and reproductive organs using clear whole

mounts/sections of the following genera:

Lycopodium, Isoetes, Selaginella, Equisetum, Psilotum, Angiopteris, Ophioglossum, Osmunda, Marsilea, Salvinia, Azolla, Lygodium, Acrostichum, Gleichenia (Dicranopteris), Pteris and *Adiantum.*

2. Study of fossil pteridophytes with the help of specimens and permanent slides.
3. Field trips to familiarize with the diversity of pteridophytes in natural habitats and submit a report.

References

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Course-4: Gymnosperms, Paleobotany & Evolution (PBT1CRT0422)

No. of Credits- 4

No. of Contact Hours: Theory 27+ 09+18= 54 Hours; Practicals 27 Hours)

Course Overview and Context:

This course is designed to enable the learner to study the morphology and anatomy of vegetative and reproductive parts of various Gymnosperms. The first four modules of this course deal with the distribution, vegetative, reproductive structures, internal structure and classification of Gymnosperms, their diversity, ecological and economic importance. The next four modules deal with Paleobotany including Geological time scale, fossils their preservation methods. Next six modules discuss Evolution, natural selection, mutation and species concept.

Course objectives and outcomes:

- Summarise the classification, distribution and economic importance of gymnosperms
- Distinguish vegetative and reproductive structures of various classes of gymnosperms.
- Explain the types of fossils and various techniques used in Palaeontology.
- Analyse the causes of organic evolution and speciation
- Interpret and integrate various theories explaining evolution.

PBT1CRT0422: GYMNOSPERMS, PALAEOBOTANY AND EVOLUTION

(Theory: 27 + 09 + 18= 54 Hours; Practical: 27 Hours) Credits: 4

GYMNOSPERMS (27 Hours)

Module 1: Introduction (3 Hours)

General characteristics, distribution and classification of gymnosperms (K R Sporne). Brief account of classification by Christenhusz *et al.*, (2011). Distribution of living gymnosperms in India.

Module 2: Vegetative and reproductive structures of Gymnosperms (20 Hours)

Detailed study of the vegetative morphology, internal structure, reproductive structures, and evolution of the orders and families (with reference to the genera mentioned).

Class Cycadopsida: *Lyginopteris, Lagenostoma, Glossopteris, Medullosa, Caytonia, Bennettites, Williamsonia, Pentoxylon, Cycas, Zamia.* Class Coniferopsida: Generalaccount of families under Coniferales, range of form and structure of stem, leaves. Range of form and structure of female cones in Coniferales -*Pinus*, *Cupressus, Podocarpus, Agathis, Araucaria, Taxus and Ginkgo*. Class Gnetopsida: *Gnetum*. General account of Ephedraceae and Welwitschiaceae

Module 3: Gametophyte development of Gymnosperms (2 Hours)

General account on the male and female gametophyte development in Cycas. Comparative study of male gametophytes of living Coniferales

Module4: Economic importance of Gymnosperms (2 Hours)

Economic importance of gymnosperms; pharmacological importance of *Ginkgo*

Practical (27 Hours)

1. Study the morphology and anatomy of vegetative and reproductive parts of *Cycas, Zamia, Pinus, Cupressus, Agathis, Araucaria, Podocarpus* and *Gnetum.*
2. Study of fossil gymnosperms through specimens and permanent slides.
3. Conduct field trips to familiarize various gymnosperms in nature and field, identification of Indian gymnosperms and submit a report.

References

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PALEOBOTANY (Theory: 9 Hours; Practical: 9 Hours)

Module 1: Introduction (1 Hour)

Evolutionary Time scale: Eras, Periods and Epochs (Including: Meghalayan, Northgrippian and Greenlandian ages).

Module2: Fossils (3 Hours)

Fossils-Definition, types. Fossilization: mode of preservation and their importance. Stages in primate evolution-including *Homo*.

Module 3: Techniques and Preservation (3 Hours)

Techniques in Palaeontology: Mega and Micro-fossils, Nanofossils, Ichnofossils- collection. Reformation and illustration- Binomial Nomenclature. Methods of Plant-fossil studies: Preservation and preparation, age determination: Carbon dating.

Module4: Nomenclature and applied aspects (2 Hours)

Fossil record: Systematic, reconstruction and nomenclature. Fossil records from India. Applied aspects of Paleobotany.

References

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EVOLUTION: (Theory: 18 Hours)

Module 1: Introduction (3 Hours)

Evolution of biomes. Mixing process, intercontinental connections. Climatic zonations, dispersal opportunities, dispersal availability, sub-climax and climax dispersal. Phylogeny and age of biomes: Interwoven biome phylogeny and biome extension and resurrection.

Module 2: Evidences for evolution (2 Hours)

Morphology, comparative anatomy, embryology, physiology, biochemistry, paleontology and biogeography. Micro and macro-evolution and punctuated equilibrium.

Module3: Natural Selection (3 Hours)

Natural selection and adaptation. Nature of natural selection, limiting factors, origin of races and species, Kins Selection and Hamilton's Rule. Rate of evolutionary change: Internal and external-factors. Significance of genetic drift in natural selection.

Module 4: Mutation as an Evolutionary Force (3 Hours)

Mutation and genetic divergence. Evolutionary significance of mutations. Genetic assimilations (Baldwin effect). Genetic homoeostasis. Mutation for natural selection. Eugenics and euthenics.

Module 5: Speciation (4 Hours)

Species concept; morphological species, biological species and evolutionary species. Mode of speciation – allopatric, sympatric and parapatric. Types of Speciation-Phyletic and true-speciation. Hybridization (Double cross hybrid of field Corn); Rate of hybridization and introgression in evolution of species. Reproductive isolation: Pre-zygotic and post-zygotic isolation.

Module 6: Co-evolution (3 Hours)

Symbiosis. Plant-animal co-evolution; mutualism, commensalism. Protective -colouration and shape. Mimicry: Batesian and Mullerian mimicry.Molecular tools in phylogeny.

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- George Ledyard Stebbins (1971). *Process of Organic evolution*.
- Gurbachan S. Miglani (2002). *Modern Synthetic theory of evolution*.
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- Volpe E. Peter (1993). *Understanding Evolution*. Universal Book Stall, New Delhi.
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MODEL QUESTION PAPERS - THEORY

M. Sc. Botany Degree (C.S.S) Examination

I Semester

Faculty of Science

PBT1CRT0122**: Microbiology and Phycology**

Time: Three hours **Max. Weight: 30**

Section- A

(Answer any **six** questions in not less than 50 words. Each question carries a weight of 1)

1. What is metagenomics?
2. Name two parasitic algae.
3. Distinguish between valve and girdle of diatoms.
4. Comment on nanobes.
5. Define Palmelloid stage, cite an example.
6. Mention the toxin and causative organism of Amnesic shell fish poisoning.
7. Mention major groups and divisions of classification by Lee.
8. How will you sterilize bacterial culture medium?

(6 x 1 = 6)

Section B

(Answer any **Seven** questions in not less than 100 words. Each question carries a weight of 2)

9. Describe the thallus structure of Phaeophyceae.

10. Describe the ultrastructure of bacterial flagella.

11. Comment on algal symbiosis.

12. Describe algal cell components.

13. Give an account on various sterilization techniques in microbiology.

14. Describe major life cycle patterns in Chlorophyceae.

15. Explain allelopathy and microalgae.

16. What are endophytes? Explain their role in plant growth promotion.

17. Describe single cell proteins with special reference to algae.

18. Explain the methods of isolation of bacterial pure cultures.

(7 x 2 = 14)

Section C

(Answer any **two** questions in not less than 250words. Each question carries a weight of 5)

19. Give a detailed account on isolation, maintenance and preservation of pure cultures of bacteria.

20. Illustrate triphasic life cycle in algae with suitable examples.

21. What are algal blooms? Describe causative organisms, symptoms and toxins of major toxic algal blooms.

22. Explain the life cycle of viruses.

(2 x 5 = 10)

M. Sc. Botany Degree (C.S.S.) Examination

I Semester

Faculty of Science

PBT1 CRT0222: **Mycology and Crop Pathology**

Time: Three hours **Max. Weight: 30**

Section A

(Answer any **six** questions. Each question carries a weight of 1)

1. What is sclerotium?
2. What is crozier formation? Give example.
3. Describe the structure of basidium.
4. Distinguish between sporangium and conidium
5. Deuteromycetes are also known as fungi imperfecti. Why?
6. What is puckering?
7. What are the disseminating methods of Bacterial Canker in Citrus Spp.?
8. What are the symptoms of Bunchy top Banana?

(6 x 1 = 6)

Section B

(Answer any **seven** questions. Each question carries a weight of 2)

9. Describe the structure of dolipore septa
10. Write short note on different type of fruiting bodies found in ascomycetes
11. Explain different type of conidial development in Duteromycetes
12. Describe the structure of spermagonium in *Puccinia graminis*
13. Illustrate the life cycle of *Physarum polycephalum*
14. Write short note on the Uredospore survival of *Puccina graminis tritici* in India

15. Write a short note on the symptoms, causativeorganismand control measures of Mahali disease of Arecanut.
16. What are the resistant verities of paddy against Bacterial blight?
17. What is meant by horizontal resistance?
18. Describe coprophilous fungi with its adaptations? Give any two examples

(7 x 2 = 14)

Section-C

(Answer any **two** questions. Each question carries a weight of 5)

19. Describe the life cycle of *Puccinia graminis tritici*. with illustrations
20. Explain the classification of Fungi by C. J. Alexopoulos and Mims.
21. Describe the symptoms, causative organism and control of Mosaic diseases.
22. What are the principles of plant disease control? Explain.

(2 x 5 = 10)

M Sc Degree (C.S.S) Examination

First semester

Faculty of science

PBT1CRT0322: **Bryology and Pteridology**

Time: Three hours **Max. Weight: 30**

Section A

(Answer any **six** questions. Each question carries a weight of 1)

1. What are endohydric bryophytes?
2. Explain the term synangium.
3. Define apospory.
4. Name two aquatic ferns.
5. What are gemma cups?
6. Write the ecological significance of bryophytes.
7. What are elaters?
8. Write the significance of heterospory.

(6 x 1 = 6)

Section B

(Answer any six questions; each question carries a weight of 2).

9. Write notes on the evolutionary significance of Psilophytales and Psilotales.
10. Describe *Lepidodendron*
11. Explain the morphological characteristics of *Psilotum.*
12. Describe vegetative reproduction in bryophytes.

13. Explain the morphology of *Ophioglossum*.
14. Write notes on heterospory and seed habit.
15. Describe the reproductive structure in *Osmunda*.
16. Write notes on conservation and cultivation of bryophytes
17. Write an account of the sporophyte of *Sphagnum*.
18. Compare the features of Psilophytales and Psilotales

(2x7= 14)

Section C

(Answer any two questions, each question carries a weight of 5)

19. Compare the features of Psilophytales and Psilotales and write notes on the evolutionary significance of these groups.
20. Describe the origin and habitat diversity of bryophytes.
21. Describe origin, organization and evolution of stele in pteridophytes.
22. Compare the gametophyte and sporophyte of hepaticopsida and bryopsida.

(2x5=10)

M. Sc. Botany Degree (C.S.S) Examination

I Semester

Faculty of Science

PBT1CRT0422**: Gymnosperms, Palaeobotany and Evolution**

Time: Three hours Max. Weight: 30

Section A

(Answer any **six** questions. Each question carries a weight of 1)

1. Mention the orders in class Cycadospsida by Sporne
2. Describe Baldwin effect
3. Name two stem genera of fossil gymnosperms
4. Define mimicry
5. What is yew wood?
6. Define copal
7. Write brief note on fossil records from India
8. Define carbon dating

(6 x 1 = 6)

Section B

(Answer any **seven** questions. Each question carries a weight of 2)

9. Mention the similarities and differences of gymnosperms with pteridophytes and angiosperms.
10. Comment on modern coniferales.
11. Distinguish between mutualism and commensalism.
12. Comment on the distribution of living gymnosperms in India
13. Describe Kins Selection and Hamilton's Rule.

14. Describe the economic importance of gymnosperms.

15. Mention the evolutionary time scale with eras and periods.

16. Describe pharmacological importance of *Ginkgo.*

17. Significance of genetic drift in natural selection.

18. Write note on speciation.

(7 x 2 = 14)

Section C

(Answer any **two** questions. Each question carries a weight of 5)

19. With suitable diagrams, describe the stelar anatomy of Medullosaceae and Pentoxylaceae

20. Describe the evidences of evolution.

21. Describe the salient features of Podocarpaceae and Araucariaceae.

22. Write an essay on speciation.

(2 x 5 = 10)

MODEL QUESTION PAPER FOR PRACTICAL EXAM

ST.ALBERT'S COLLEGE (AUTONOMOUS) ERNAKULAM

MSC BOTANY SEMESTER I - PRACTICAL EXAM

PBT1CRP0122: MICROBIOLOGY, PHYCOLOGY, MYCOLOGY AND CROP PATHOLOGY

Time: 4 hours Weightage: 15

1. Make suitable micropreparations of A and B. Draw labeled diagrams and identify giving reasons.

(Total weight 1.5= Preparation– 0.5, Diagram– 0.5, Identification with reasons – 0.5; 1.5x 2 = 3).

2. Write critical notes on C and D. (Correct identification with critical note – 0.5; 0.5 x 2 = 1)

3. Sort out any four algae from the algal mixture E and make separate clear mounts. Identify and draw labeled diagrams.

(Total weight 1 = Preparation – 0.5, Identification with diagrams – 0.5; 1 x 4 = 4).

4. Spot at sight F and G. (Total weight 1 = Identification 0.5, Part displayed = 0.5; 1 x 2 = 2)

5. Identify the disease in H and I and write the causative organism.

(Correct identification of the disease and causative organism – 0.5; 0.5 x 2 = 1)

6. Isolate Bacteria from the soil sample J by serial dilution and Spread plating.

(Total weight 1 = Working – 0.5, Procedure – 0.5)

7. Submit five specimens of plants showing typical disease symptoms (Total weight 1)

8. Practical record (Total Weight = 2)

Key to the questions:

1. A, B: Alga, Fungi/Lichen.

2. C, D - Fungi.

3. E – Algal mixture containing five filamentous types.

4. F, G – Macroscopic or microscopic specimens from algae, fungi/lichen with clear and distinguishable identifying characters.

5. H, I – Herbarium or live/dry specimen showing the symptoms of any disease specified in the syllabus

6. J - Supply necessary soil sample.

7. Awarding 'A grade' for the record of practical work shall be considered only if all the practical works specified in the syllabus are done completely and recorded properly. This also includes field study report(s)/Lab visit report(s), if any.

ST.ALBERT'S COLLEGE (AUTONOMOUS) ERNAKULAM

M.Sc. BOTANY SEMESTER I - PRACTICAL EXAMINATION

PBT1CRP0222: BRYOLOGY, PTERIDOLOGY, GYMNOSPERMS AND PALEOBOTANY

Time: 4 hours Weightage: 15

1. Make stained micro-preparations of specimens A, B and C. Draw labelled diagrams for each and identify giving reasons.

(Total weight 1.5 = Preparation – 0.5, Diagram – 0.5, Identification with reasons – 0.5; 1.5 x 3 = 4.5).

3. Make stained micro-preparations (TS, TLS and RLS) of D. Draw labeled diagram and identify giving reasons.

(Total weight 2.5 = Preparations – 0.5 (0.5 x 3 = 1.5; Identification with reasons and diagrams – 1).

4. Identify at sight E, F, G and H.

(Total weight 1 = Genus identification - 0.5, Part displayed -0.5; 1 x 4 = 4).

5. Write critical notes on the reproductive structures I and J.

(Correct identification with critical note – 0.5; 0.5 x 2 = 1).

6. Identify and write a critical note on K.

(Total weight 1 = Identification – 0.5, Critical note – 0.5) = 1.

6. Practical record (Total weight= 2)

Key to the questions:

1. A, B, C – one each from Bryophytes, Pteridophytes and Gymnosperm leaf.

2. D - Suitable specimen from Coniferales.

3. E, F, G, H – Suitable specimens from Bryophytes, Pteridophytes and Gymnosperms; both reproductiveand/or vegetative structures; should not exceed two specimens from one group.

4. I, J – Specimens from Bryophytes, Pteridophytes or Gymnosperms.

5. K - Fossil slides/specimens/photographs of types specified in the syllabus; both vegetative and reproductive structures included.

6. Awarding 'A grade' for the record of practical work shall be considered only if all the practical works specified in the syllabus are done completely and recorded properly. This also includes field study report(s)/Lab visit report(s), if any.

Detailed Syllabus: Semester II

Course Code	Name of the Course
PBT2CRT0122	Plant Anatomy, Developmental Biology & Horticulture
PBT2CRT0222	Cell Biology, Genetics &Plant Breeding
PBT2CRT0322	Plant Physiology & Biochemistry
PBT2CRT0422	Molecular Biology
PBT2CRP0122	Plant Anatomy, Developmental Biology &Horticulture + Cell Biology, Genetics &Plant Breeding (PRACTICAL)
PBT2CRP0222	Plant Physiology & Biochemistry+ Molecular Biology (PRACTICAL)

Total credits: 19

Total hours: 450

Course-1: Plant Anatomy, Developmental Biology & Horticulture (PBT2CRT0122)

No. of Credits- 4

No. of Contact Hours: Theory 36+ 18+18= 72 Hours; Practicals 27+09+09=45Hours)

Course Overview and Context:

This course is focused on revealing the structure and development of plants. It explores the internal tissue organization of higher plants. Laboratory practicals will help the learners to know more about the anatomy practices and methods and will enable them to master the art of sectioning and also the use of double staining for slide preparation. The learners would get an opportunity to know more about the embryonic developmental stages of higher plants. They would also gain hands-on experience and skill in horticultural practices.

Course objectives and outcomes:

- Explain the anatomical features and functions of various plant tissues.
- Distinguish between the anatomical features of various reproductive parts, primary and secondary structures of vegetative parts.
- Comparison of different types of stomata, nodal patterns, anthers, ovules, embryogeny and endosperm development in various angiosperms.
- Identify and chart out the developmental stages in the life-cycle of Angiosperms.
- Apply knowledge of traditional and modern practices in Horticulture for plant propagation and developing bonsai, terrarium, aquaponics, etc.

PBT2CRT0122: PLANT ANATOMY, DEVELOPMENTAL BIOLOGY AND HORTICULTURE

(Theory: 36 + 18+ 18= 72 Hours; Practical: 27 + 09 + 09= 45 Hours) Credits: 4

PLANT ANATOMY (Theory: 36 Hours; Practical: 27 Hours)

Module 1: Introduction (1 Hour)

Scope and significance of plant anatomy. Role of anatomy in phylogeny.

Module 2: Meristem (4 Hours)

Shoot Development, Apical Meristem and types of vegetative shoot apex in Angiosperms, Cytological zonation, Sub-apical differentiation of tissues, Root Development, Organization of root apex. Origin of branches. Primary Thickening Meristem (PTM) in Monocots. Secretory tissues in plants. Structure and distribution of secretory trichomes (e.g. *Drocera*, *Nepenthes*), Salt glands, collectors, nectaries, resin ducts and laticifers.

Module 3: Secondary Structure (16 Hours)

Mechanical tissues in plants. Structure and functions. Vascular cambium and cork cambium: Structure and functions. Factors affecting cambial activity. Secondary xylem: ontogeny, structure, components and functions. Origin of vessel in angiosperms and dilation of rays. Axial parenchyma distribution in wood. Secondary phloem: Ontogeny, structure, components and functions. Stelar

and extra stelar thickening in angiosperms. Reaction wood, compression wood and tension wood. Factors affecting reaction wood formation. Dendrochronology: Growth rings and their functions. Summer and Spring-wood. Anomalous secondary growth in dicots and monocots. Tyloses: Structure and function. Plant fibres: distribution, structure and commercial importance of coir, jute, and cotton. Root-stem transition in angiosperms.

Module 4: Leaf and Node (4 Hours)

Leaf: ontogeny and structure of leaf. Structure, development and classification of stomata and trichomes. Leaf abscission. Nodal anatomy: unilacunar, trilacunar and multilacunarnodes, nodal evolution; role of nodal anatomy in taxonomy.

Module 5: Reproductive Anatomy (8 Hours)

Floral anatomy: Anatomy of floral parts - sepal, petal, stamen and carpel, vascular anatomy of flower and modifications. Development of epigynous ovary-appendicular and receptacular theory, role of floral anatomy in taxonomy. Fruit and seed anatomy - anatomy of fleshy and dry fruits - follicle, legume and berry. Dehiscence of fruits. Anatomy of seeds.

Module 6: Applied Anatomy (3 Hours)

Research prospects in anatomy. Applications of Anatomy in Systematics (Histotaxonomy) and Pharmacognosy.

Practical (27 Hours)

1. Study the Anomalous- Primary and Secondary features in:

Bignonia, *Amaranthus*, *Nyctanthes*, *Piper*, *Bougainvillea* and *Strychnos*.

2. Study of nodal patterns (Unilacunar. Trilacunar and Multilacunar).

3. Double staining procedure for transverse sections of dicot stem and dicot leaf.

References

- Charles B. Beck (2010). An Introduction to Plant Structure and Development_ Plant Anatomy for the Twenty-First Century. Cambridge University Press.

- David F. Cutler, Ted Botha, Dennis W. M. and Stevenson (2008). Plant Anatomy: An Applied Approach.Wiley-Blackwell.
- Eames A. J, Mc Daniel (1976). An introduction to plant Anatomy.
- Edred John Henry Corner (1976). The seeds of dicotyledons (Vol. I & II). Cambridge University Press.
- Elizabeth G. Cutter (1978). Applied Plant Anatomy. Clive and Arnald Ltd.
- Elizabeth G. Cutter (1978). Plant anatomy part I & II. Clive and Arnald Ltd.
- Ella Werker (1997). Seed Anatomy. Borntreager.
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- Esau K. (1977). Anatomy of seed plants. Wiley and sons.
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- Fritz Hans Schweingruber, Annett Borner and Ernst-Detlef Schulze (2008). Atlas of Woody Plant Stems. Evolution, Structure, and Environmental Modifications. Springer.
- Ingrid Roth (1977). Fruits of Angiosperm. Gebruder Borntreager.
- John A. Romberger, Zygmunt Hejnowicz and Jane F. Hill (2005). Plant Structure Function and Development. A Treatise on Anatomy and Vegetative Development, with Special Reference to Woody Plants. Sherwin Springer-Verlag.
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- Pandey B. P. Plant Anatomy. S Chand and Co. New Delhi.
- Paula J. Rudall (2007). Anatomy of Flowering Plants. An Introduction to Structure and Development. Cambridge University Press.
- Ray F. Evert, Susan E. and Eichhorn (2007). Esau's Plant Anatomy: Meristems, Cells, and Tissues of the Plant Body, Their Structure, Function, and Development.Wiley-Liss.

- John Carlquist (2001). Comparative wood anatomy: Systematic, ecological, and evolutionary aspects of dicotyledon wood.
- Taylor A. Steeves, Vipen K. Sawhney (2017). Essentials of developmental plant anatomy.Oxford University Press.
- Vasishta P. C. (1994). Plant anatomy. Pradeep publications.
- William C. Dickison (2000). Integrative plant anatomy. Academic Press.

DEVELOPMENTAL BIOLOGY (Theory: 18 Hours+ Practical: 9 Hours)

Module 1: History and Basic Concepts of Development (5 Hours)

Overview on the modern era of Developmental Biology emerged through multidisciplinary approaches. Stages of development- zygote, blastula, gastrula, neurula. Cell fate and commitment, potency- concept of embryonic stem cells, differential gene expression, terminal differentiation, lineages of three germ layers, fate map. Mechanisms of differentiation-cytoplasmic determinants, embryonic induction, concept of morphogen, mosaic and regulative development. Pattern formation-axis specification, positional identification (regional specification). Morphogenetic movements. Model organism in developmental biology (Arabidopsis-brief account only)

Module 2: Overview of Plant Development (9 Hours)

Angiosperm life cycle. Anther: microsporogenesis and microgametogenesis. Viability of pollen grains. Pollination, pollen germination, growth and nutrition of pollen tube, pollen morphology, exine sculpturing, pollenkitt, NPC formula. Ovule: megasporogenesis and megagametogenesis. Types of embryosac and development. Fertilization: Double fertilization; embryo development - different types. Endosperm development, types of endosperm, haustorial behaviour of endosperm. Xenia and metaxenia. Polyembryony – types and causes. Seed formation, dormancy and germination. Apomixis, Parthenogenesis.

Module 3: Morphogenesis and Organogenesis in Plants: (4 Hours)

Organogenesis in plants, transition to flowering, floral meristems and floral development. Homeotic genes in plants.

Practical (9 Hours)

1. Embryo excision from young seeds.
2. Identification of different types of ovules, embryos, polyembryony, endosperm, pollen grains, anther growth stages.

References

- Scott F Gilbert (2000). Developmental Bilogy (IX Edn). Sinauer Associates.
- R M Twyman (2001). Instant notes in Developmental Biology. Viva Books Private Limited.
- Lincoln Taiz, Eduardo Zeiger (2002). Plant physiology (II Edn). Sinaeur Associates, Inc. Publishers.
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- S S Bhojwani, S P Bhatnagar (1999). The Embryology of Angiosperms (IV Edn). Vikas Publishing House Pvt Ltd.
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HORTICULTURE (Theory: 18 Hours Practical: 9 Hours)

Module 1: Introduction (2 Hours)

Introduction to Horticulture; nature and scope. Objectives of horticulture.

Module 2: Principles of Horticulture (4 Hours)

Principles of landscape gardening. Gardening: ornamental and indoor gardens, kids gardens, vertical and roof top gardens. Garden adornments. Propagation methods-layering, budding, grafting, and micropropagation-merits and demerits.

Module 3: Horticulture Applications (6 Hours)

Composting: aerobic, anaerobic and vermicomposting; mist chamber, green house and glass house. Effect of pollution on indoor plants. Commercial products of horticulture. Olericulture: home and market - gardening and truck farming. Seed production.

Module 4: Floriculture (3 Hours)

Introduction, nature and scope. Fresh and dry flower arrangements. Production of Cut flowers, cultivation of orchids, foliage potted plants and bedding plants. Future prospects of floriculture.

Module 5: Modern trends in horticulture (3 Hours)

Bonsai: Selection of plants and making of bonsai. Physical control of plant growth in Bonsai preparation. Preparation of terrarium, aquaponics and arbori culture. Components of high-tech farming.

Practical: (9 Hours)

1. List out the Garden components in the Photograph.
2. Demonstration of Preparation of a Terrarium.
3. Propagation methods-layering and grafting: A **hands-on-training** in a well-established nursery is intended for the students in order to procure necessary skill and expertise in the grafting and layering procedure. The field report (in record) along with a grafted/layered potted plant must be submitted for evaluation.

References

- Adam C.R. (2004). Principles of Horticulture. Elsevier Butterworth-Heinemann.
- Peter K. V. (2015). *Basics of Horticulture*. New India Publishing Agency, New Delhi.
- Gupta S.N. (2016). *Instant Horticulture*. Jain Brothers, New Delhi.
- Tiwari A.K. and R. Kumar (2012). *Fundamentals of Ornamentals, Horticulture andLandscape Gardening*. New India Publishing Agency, New Delhi.

Course-2: Cell Biology, Genetics & Plant Breeding (PBT2CRT0222)

No. of Credits- 4

No. of Contact Hours: Theory 27+ 27+18= 72 Hours; Practicals 18+18+9=45 Hours)

Course Overview and Context:

This course examines the structure and functions of cells and cell organelles, cell division, cell cycle and cell signaling and communication. The course in genetics aimed to introduce the learner from classical to modern aspects of molecular genetics. It also helps in providing conventional and modern approaches in improving crop plants.

Course objectives and outcomes:

- Examine the intracellular organelles and associated life process, cell signalling and communication, cell cycle events and its regulation mechanisms.
- Apply principles of genetics and solve problems on linkage, crossing over and gene mapping.
- Explain the concepts and principles of population genetics
- Familiarize the students with objectives and methods of plant breeding
- Develop and design the traditional and modern methods of crop improvement

PBT2CRT0222: CELL BIOLOGY, GENETICS AND PLANT BREEDING

(Theory: 27+27+18=72Hours; Practical: 18+18+9=45 Hours; Credits: 4)

CELL BIOLOGY (Theory: 27 Hours; Practical: 18 Hours)

Module 1: Introduction to plant cells (7 Hours)

Structural organization of plant cell. Plasma membrane – chemical composition, organization, membrane fluidity, dynamic nature. Ultrastructure and functions of mitochondria, peroxisomes, glyoxysomes and chloroplast. Endomembrane system – structure and functions of endoplasmic reticulum, Golgi complex, lysosomes and vacuoles. Transport of materials – biosynthetic (secretory) and endocytic pathway. Chromosomes – organization of chromatin and chromosomes

- histones and nonhistone proteins, nucleosomal organization of chromatin, higher levels of chromatin organization in chromosomes. Heterochromatin and Euchromatin, formation of heterochromatin. Molecular structure of the Centromere and Telomere.

Module 2: Cell signaling (6 Hours)

Cell communication - general principles. Signaling molecules and their receptors; external and internal signals that modify metabolism, growth, and development of plants. Receptors: cell surface receptors - ion-channel linked receptors (Voltage-gated ion channels and Ligand-gated ion channels in neurons), G-protein coupled receptors (β-adrenergic receptor), Tyrosine-kinase linked receptors (Insulin receptor), and Steroid hormone receptors (Estrogen receptor). Signal transduction pathways, second messengers, regulation of signaling pathways. Bacterial and plant two-component signaling systems (Brief study).

Module 3: Cell interaction (4 Hours)

Extra cellular matrix, Cell adhesion molecules - cadherins, integrins, selectins, fibronectins, laminin and Immunoglobin superfamily. Cell-cell adhesions (Junctional and non-junctional adhesive mechanisms; occluding junctions, anchoring junctions, communicating junctions (Connexons and plasmodesmata).

Module 4: Cytoskeleton (3 Hours)

Functions of cytoskeleton; Structure, assembly, disassembly and regulation of filaments involved – actin filaments (microfilaments), microtubules, and intermediate filaments. Molecular motors – kinesins, dyneins, and myosins.

Module 5: Cell cycle and its regulation (7 Hours)

Phases of cell cycle, mitosis and meiosis (Brief study), Spindle formation and its disintegration, Mechanisms of chromosome movement and separation during anaphase, Role of cohesins and condensins. Role of motor proteins. Cell cycle control mechanisms - extracellular an intracellular signals. Cell cycle checkpoints – DNA damage checkpoint, centrosome duplication checkpoint, spindle assembly checkpoint - role of cyclins and cyclin dependent kinases. Apoptosis – process of programmed cell death, extrinsic and intrinsic pathways of apoptosis.

Practical (18 Hours)

1. Identification of different stages of mitosis and study of morphology of metaphase chromosomes from Onion root meristems (Recorded by photomicrographs).
2. Identification of different stages of meiosis from suitable plant material (Recorded by photomicrographs).
3. Microscopic observation (Chloroplast).
4. Study of mitotic index from suitable plant material.

References

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- Gerald Karp (2008). *Cell and Molecular biology: Concepts and experiments* (V Edn). John Wiley & Sons
- George Plopper, David Sharp, Eric Sikorski (2015). *Lewin's Cells* (III Edn). Jones and Bartlett Learning.
- Harvey Lodish, Arnold Berk, Chris A. Kaiser, Monty Krieger, Matthew P. Scott, Anthony Bretscher, Hidde Ploegh, Paul Matsudaira (2007). *Molecular cell biology* (VI Edn). W H Freeman & Company.
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- Geoffrey M Cooper, Robert E Hausman (2009). *The Cell: A molecular approach* (V Edn). Sinaeur.
- Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, Peter Walter (2002). *Molecular biology of the cell* (IV Edn). Garland Science, Taylor and Francis group.
- Bruce Alberts, Dennis Bray, Karen Hopkin, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, Peter Walter (2010). *Essential Cell Biology*. Garland Science.
- David E Sadava (2009). Cell biology: Organelle structure and function. CBS.

GENETICS (Theory: 27 Hours; Practical: 18 Hours)

Module 1: Genetics - From "Factors" to "Genes" and gene interactions (6 Hours)

Introduction to Mendelian genetics and principles of inheritance; Extensions of Mendelism (Brief study).Model organisms in Genetics - *Arabidopsis thaliana*, *Neurospora crassa*, *E. coli*, *Drosophila melanogaster* and *Caenorhabditis elegans* (Brief study).Linkage, crossing over andchromosomemapping in eukaryotes. Cytoplasmic inheritance, multiple alleles,quantitative inheritance, QTL; Penetrance and expressivity, Sex determination in plants and animals, X-chromosomeinactivation in mammals – dosage compensation.

Module 2: Human Genetics and Cancer (9 Hours)

Inheritance of traits in Humans - Pedigree analysis(Nail Patella Syndrome and ABO locus) , genetic disorders in humans - autosomal recessive - ADA deficiency, Sickle cell anemia; autosomal dominant - Huntington's chorea, familial hypercholesterolemia; inborn errors of metabolism - phenylketonuria, Alkaptonuria, Albinism. Cancer - a genetic disease; Cancer and cell cycle, oncogenes, chromosome rearrangements and cancer (Philadelphia Chromosome), Tumour suppressor genes, causes of cancer, properties of cancer cells, types of cancer, Genetic pathways to cancer

Module 3: Mutations (4 Hours)

Classification and types: Chromosomal mutations - changes in structure and number; Gene mutations, Effect of different mutagens on the structure of DNA.

Module 4: Population Genetics (8 Hours)

Emergence of evolutionary theory and population genetics; Concepts in population genetics - Gene pool, Gene frequency, genotype frequency; Hardy Weinberg's Law and its applications; Exceptions to Hardy-Weinberg's Principle; Factors affecting gene frequency - Mutation, selection, migration, natural selection and Genetic drift (Bottle neck effect and Founder effect); Populations in Genetic equilibrium - balancing selection, mutation-selection balance, mutation drift balance. Speciation - pre-zygotic and post-zygotic isolation (Brief account); modes of speciation - Allopatric, sympatric and parapatric.

Practical (18 Hours)

1. Workout problems related to linkage, crossing over and gene mapping, human pedigree analysis, Cytoplasmic Inheritance, Multiple alleles and quantitative inheritance.
2. Work out problems in population genetics-gene and genotype frequency, Hardy-Weinberg equilibrium.

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PLANT BREEDING (Theory: 18 Hours; Practical 9 Hours)

Module 1: Introduction (2 Hours)

Objectives of plant breeding, important achievements and future prospects. Domestication and centres of origin of cultivated plants.

Module 2: Hybridization (3 Hours)

Hybridization-role and methods, inter-varietal, inter-specific and inter-generic crosses. Incompatibility and male sterility in plant breeding (brief account). Back-cross breeding. Heterosis, inbreeding depression.

Module 3: Idiotype breeding (2 Hours)

Role and methods, applications of idiotype breeding.

Module 4: Breeding for resistance (3 Hours)

Breeding for biotic (disease) and abiotic (drought) stresses; loss due to diseases, disease development, disease escape, disease resistance, vertical and horizontal- resistances of biotic stress; methods of breeding for disease resistance.

Module 5: Mutation breeding (6 Hours)

Mutagens and crop improvement. Spontaneous and induced mutations, effects of mutation. Physical and chemical mutagens; principles and working of gamma gardens, methods of mutation breeding, mutations in oligogenic traits, mutations in polygenic traits, limitations of mutation breeding, achievements of mutation breeding.Role of mutation in plant breeding.

Module 6: Modern breeding methods (2 Hours)

Modern trends in plant breeding: Tissue culture technologies (DNA marker-assisted Selection (MAS) - a brief study only).

Practical: (9 Hours)

1. Hybridization techniques in self and cross pollinated plants.
2. Estimation of pollen sterility through in-vitro germination/staining-technique.
3. Visit a Plant Breeding station to familiarize with breeding programmes. Submit a report of the visit.

References

- Allard R. W. (1995). *Principles of Plant Breeding*. John Wiley and Sons, Inc.
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- Singh B. D. (1996). *Plant Breeding: Principles and methods*. Kalyani Publications.

COURSE-3: PLANT PHYSIOLOGY & BIOCHEMISTRY (PBT2CRT0322)

No. of Credits- 4

No. of Contact Hours: Theory 45+ 27= 72 Hours; Practicals 45+27 Hours=72 Hours)

Course Overview and Context:

This course will provide the core concepts in plant water relations, absorption of minerals, photosynthesis, respiration, stress physiology and plant growth regulators. It includes a comprehensive knowledge about the structure and function of the important biomolecules. The context is to introduce the learner from fundamentals of various biochemical and physiological processes in plants and also to the recent developments taking place in the subject area.

Course objectives and outcomes:

- Describe the physiology regulating water and mineral absorption and translocation in plants and the significance of nitrogen metabolism.

- Describe the concept of light harvesting by plants in response with varying environmental conditions and identify the role of Plant Growth Regulators in development of entrepreneurship in the area of plant physiology
- Judge and evaluate the biochemical mechanisms involved in the energy generating process of respiration and the understanding of the same in relation to stressed conditions in plants.
- Examine the structure and function of important biomolecules and understand their importance in the maintenance of living systems.
- Assess the structure, kinetics and regulation of enzymes and design methodologies for isolation, purifying and modifying enzymes.

PBT2CRT0322: PLANT PHYSIOLOGY AND BIOCHEMISTRY

(Theory 45+27 =72 Hours; Practical 36+27=63 Hours; Credits: 4)

PLANT PHYSIOLOGY (Theory: 45 Hours; Practical: 45 Hours)

Module 1: Transport and Translocation of water and solutes (8 Hours)

a) Absorption and translocation of water, apoplast and symplast, pathways of water uptake and transport, xylem transport, passive and active transport. Aquaporins. Water pathway in the leaf – driving force of transpiration, leaf anatomy for regulating transpiration. Stomatal biology – light dependent stomatal opening. Soil-plant-atmosphere continuum.

b) Absorption of minerals: Soil characters influencing nutrient availability – size and charge of soil particles, soil pH. Mechanism of entry of minerals into roots.

c) Transport of ions, solutes and macromolecules: Electrical properties of membranes, Membrane potential. Transport across cell membranes: Passive – diffusion, facilitated diffusion, membrane channels; plasmodesmata, porins, ion channels – gated channels, structure and working of K^+ ion channels. Active transport: Carrier proteins; P-type H^+ ATPase, ABC transporters.

Module 4: Photosynthesis (12 Hours)

a) Light harvesting complexes: PS I, PSII; Structure and composition of reaction centers. Basic principles of light absorption, excitation energy transfer, mechanism of electron

transport, photooxidation of water, proton electrochemical potential – photophosphorylation.

b) Structure and function of RuBisco, CO_2 fixation – Calvin cycle. Photorespiration, role of photorespiration in plants. CO_2 concentrating mechanisms – algal and cyanobacterial pumps, C4 cycle, CAM pathway. Synthesis of starch and sucrose, photosynthetic quantum yield and energy conversion efficiency. Transport of photoassimilates – phloem loading and unloading, mechanism of phloem translocation – pressure flow. Thylakoid ET inhibitors, Photoinhibition and its tolerance mechanism.

Module 5: Respiration (10 Hours)

Three stages of respiratory metabolism (brief study only). Plant mitochondrial electron transport and ATP synthesis – organization of electron transfer complexes (complex I – IV). ATPase (Complex V) – detailed structure of F1 and Fo subunits, binding change mechanism of ATP synthesis. Comparison of mitochondrial and chloroplast ATP synthesis. Cyanide resistant pathway - alternative oxidase, its regulation and significance. Rotenone-insensitive pathway in plants.

Module 6: Nitrogen metabolism: (4 Hours)

N cycle. N fixation processes. Biological N fixation – structure of nitrogenase complex, reduction of N. Symbiotic N fixation – nodule formation, nodulin gene and nodulation genes, leghaemoglobin. Nitrate and ammonium assimilation. Transport of amides and ureides.

Module 7: Stress physiology (4 Hours)

Plant stress - biotic and abiotic. Stress sensing mechanisms in plants. Acclimation and adaptation mechanisms in plants.

Module 8: Sensory photobiology (4 Hours)

Plant photoreceptors - phytochromes, cryptochromes and phototropins, their function and mechanism of action. Photoperiodism and biological clocks – circadian rhythms. Floral induction and development.

Module 9: Plant growth regulators (3 Hours)

Physiological effects and mechanism of action of plant growth hormones. Role of elicitors in growth regulation.

Practical **(45 Hours)**

a) Measurement of Photosynthesis - Hill Reaction.

b) Estimation of proline in plant tissues under various abiotic stresses.

c) Estimation of phenol in plant tissues affected by biotic stress.

d) Determination of peroxidase activity in plant tissues affected by biotic/abiotic stresses.

e) Estimation of free amino acids in senescing leaves to understand the source to sink transformation phenomenon.

f) Determination of osmotic potential by tissue weight method.

g) Separation of photosynthetic pigments by TLC/paper chromatography and calculating the Rf value

h) Demonstration of amylase activity and GA effect in germinating cereal seeds.

i) Estimation of total chlorophyll and study of absorption pattern of chlorophyll solution.

j) Separation and collection of leaf pigments by silica gel column chromatography.

k) Determination of nitrate reductase activity.

l) Extraction and estimation of leghaemoglobin from root nodules.

References

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BIOCHEMISTRY (Theory: 27 Hours; Practical 27 Hours)

Module 1: Introduction (2 Hours)

Acid and Bases, ionisation of water, dissociation of acids, Henderson-Hasselbalch equation, pKa.

Buffers - Common buffers (acetate, citrate and phosphate), buffer action, buffer capacity.

Measurement of pH.

Module 2: Carbohydrates (4 Hours)

General structure and biological importance of carbohydrates. Monosaccharids and Oligosaccharides: classification and structure with common examples. Polysaccharides: Classification, structure and functions - starch, cellulose. Glycoproteins and glycolipids.

Module 3: Lipids (5 Hours)

(a) Classification, important biological functions. Structure of fatty acids, triglycerides, waxes, Phosphoglycerides and Sterols. Lipids with biological specific activities – steroids and

isoprenoids. (b) Lipid metabolism in oilseeds – Oxidation of fatty acids, glyoxylate cycle, gluconeogenesis.

Module 4: Amino acids and proteins (5 Hours)

Classification and structure of aminoacids, peptide bond. Structure and functions of protein – primary, secondary, tertiary and quaternary structure. Ramachandran plot, alpha helix and beta conformations. Protein degradation in cells (brief account).

Module 5: Enzymes (7 Hours)

a) Classification and naming, IUB system.

b) Mechanism of enzyme action. Measurement and expression of enzyme activity, factors affecting enzyme activity.

c) Enzyme kinetics - Michaelis-Menten kinetics, Lineweaver-Burk plot.

d) Regulation of enzyme activity. Enzyme inhibition

e) Co-enzymes and co-factors, Ribozymes and Abzymes.

f) Enzyme technology - isolation and purification of enzymes, modifying enzymes for stability (brief study).

Module 6: Secondary metabolites (4 Hours)

Classification, Biosynthesis and functions of terpenoids, alkaloids and phenolics.

Practical (27 Hours)

1. Preparation of buffers-Citrate and Phosphate-various strengths.
2. Quantitative estimation of reducing sugar.
3. Separation of amino acids by TLC.
4. Quantitative estimation of protein (Lowry's method).
5. Preparation of Molar, Normal, Percentage and PPM solutions and their dilutions.
6. Estimation of total phenolics in plant tissue.
7. Isolation and estimation of amylase from germinating seeds.

References

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- David L Nelson, Michael M Cox (2013). Lehninger Principles of Biochemistry (VI Edn). Macmillan International.
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COURSE-4: MOLECULAR BIOLOGY (PBT2CRT0422)

No. of Credits- 3

No. of Contact Hours: Theory 54 Hours; Practicals 18 Hours)

Course Overview and Context:

The course covers the structure and function of cell organelles and chromosomes and DNA. It emphasizes on the DNA and the mechanisms of its replication and repair, gene expression and regulation and helps the students to analyze these mechanisms in the prokaryotic and eukaryotic systems.

Course objectives and outcomes:

- Distinguish between the structure and function of different types of genetic material.
- Explain the molecular mechanisms of gene expression.
- Differentiate between the form and functioning of DNA, RNA and protein.
- Explain the mechanism of regulation of gene expression
- Correlate between mode of gene expression and functioning of an organism.

PBT2CRT0422: MOLECULAR BIOLOGY

(Theory 54 Hours; Practical 18 Hours; Credits: 3)

Module 1: Nucleic acids (6 Hours)

a) **Molecular structure of DNA:** Watson and Crick model, alternative conformations, DNA triplex and quadruplex, imotif. DNA supercoiling – Topoisomerases.

b) **Structure, Diversity and Versatility of RNA:** Primary, secondary, tertiary and quaternary structure of RNA. RNA as genetic material – plus, minus, double stranded RNA. Catalytic RNA: Ribozymes – Discovery, structure, mechanism and functions; HDV ribozyme, hammerhead ribozymes, self-splicing introns, RNaseP, RNase MRP, Peptidyl transferase. Noncoding RNA: Structure and biological roles of rRNA, tRNA, tmRNA, siRNA miRNA, piRNA, lncRNA (Xist, HOTAIR) and circular RNA.

Module 2: Organization of the Genome (4 Hours)

a) Genome organization in viruses, bacteria, and eucaryotes. Organellar genome – structure and organization, important organellar genes.

b) Eukaryotic nuclear genome: c-value paradox, DNA renaturation kinetics, Tm, Cot curve. Unique and Repetitive DNA – mini- and microsatellites.

Module 3: Replication of the Genome (6 Hours)

(a) RNA replication: By RNA-dependent RNA polymerase, retroviral RNA replication.

(b) DNA replication: Unit of replication, enzymes and proteins involved in replication (in both prokaryotes and eukaryotes). Structure of the replication origin (in both prokaryotes and eukaryotes), priming (in both prokaryotes and eukaryotes), replication fork, fidelity of replication.

Process of replication – initiation, elongation and termination. Replication in the telomere - telomerase.

Module 4: Gene Expression (14 Hours)

a) **Gene**: Concept of gene; structural and genetic definitions–complementation test.

b) **Transcription in prokaryotes**: Initiation–promoter structure, structure of RNA polymerase,structure and role of sigma factors. Elongation – elongation complex, process of RNA synthesis. Termination – rho-dependent and rho-independent termination.

c) **Transcription in eucaryotes**: Types, structure and roles of RNA polymerases. Promoters–important features of class I, II, & III promoters. Enhancers and silencers. General transcription factors and formation of pre-initiation complex. Elongation factors, structure and function of transcription factors.

d) **Post-transcriptional events**: Split genes, splicing signals, splicing mechanisms of group I, II, III, and tRNA introns. Alternative splicing, exon shuffling, *cis*- and *trans*-splicing. Structure, formation and functions of 5' cap and 3' tail of mRNA, RNA editing, mRNA export.

e) **Genetic code**: Important features of the genetic code, proof for the triplet code, Exceptions to the standard code.

f) **Translation**: Important features of mRNA–ORF, RBS. Fine structure, composition and assembly of prokaryotic and eukaryotic ribosomes. tRNA charging, initiator tRNA.

g) **Stages in translation**: Initiation–formation of initiation complex in prokaryotes and eukaryotes, initiation factors in prokaryotes and eukaryotes, Kozak sequence. Elongation – process of polypeptide synthesis, active centers in ribosome - 3-site model, peptidyl transferase, elongation factors. Termination – process of termination, release factors, ribosome recycling.

h) **Protein sorting and translocation**: Cotranslational and posttranslational–signal sequences, SRP, translocon. Membrane insertion of proteins. Post-translational modification of proteins. Protein folding – self assembly, role of chaperones in protein assembly.

Module 5: Control of Gene Expression (10 Hours)

(a) Viral system: Genetic control of lytic and lysogenic growth in λ phage, lytic cascade.

a) **Prokaryotic system**: Transcription switches, transcription regulators. Regulation oftranscription initiation; Regulatory proteins - activators and repressors. Structure of *Lac* operator, CAP and repressor control of *lac* genes. Regulation after transcription initiation – regulation of amino acid biosynthetic operons - attenuation of trp operon, riboswitches.

b) **Eukaryotic system**: Changes in chromatin and DNA structure–chromatin compaction,mechanism of action of activators and repressors, gene amplification, gene rearrangement, alternate splicing, gene silencing by heterochromatization, and DNA methylation. Effect of regulatory transcription factors on transcription. Post-transcriptional control – mRNA stability. Small RNA mediated control.

Module 6: Recombination (5 Hours)

Homologous and nonhomologous recombination, molecular mechanism of homologous recombination. Site-specific recombination, transposition - types of transposons.

Module 7: Epigenetic inheritance (4 Hours)

Genomic imprinting, Cytosine methylation, Histone code, ncRNA and epigenetics

Module 8: Mutation repair (5 Hours)

DNA repair mechanisms: Direct repair, Excision repair–base excision repair and nucleotide excision repair. Mismatch repair, Recombination repair – homologous recombination repair, nonhomologous end joining, SOS response – Translation DNA polymerase.

Practical (18 Hours)

1. Work out problems based on DNA structure, replication, gene expression and genetic code (Genetic code chart may be brought for reference during examination).

References

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- Burton E Tropp (2012). *Molecular biology: Genes to Proteins* (IV Edn). Jones and Bartlett

Learning.

- Lynne Cassimeris, Viswanath R Lingappa, George Plopper (Eds) (2011). *Lewin's Cells* (II Edn). Jones and Bartlett Publishers.

MODEL QUESTION PAPERS– THEORY

M Sc Botany Degree (CSS) Examination

II Semester Faculty of Science

PBT2CRT0122: PLANT ANATOMY, DEVELOPMENTAL BIOLOGY AND HORTICULTURE

Time: 3 hours **Max. Weight: 30**

Section A

(Answer any **six** questions. Each question carries a weight of 1)

1. What is meant by abiogensis?
2. Write brief notes on

   a) Moleculae clock b) Eras
3. Describe the economic importence of Plant fibers.
4. Describe the structure and fuction of wood parenchyma.
5. Describe the horticultural implement used for weeding.
6. What is double fertilization?
7. What is tension wood?
8. Describe different parts of stem apex.

(6 x 1 = 6)

Section B

(Answer any **Seven** questions. Each question carries a weight of 2)

9. Explain collateral and open vascular bundle with examples?
10. Define hydrophytes. Give morphological and anatomical characters.
11. Write a note on evolutionary time – scale?
12. Describe the structure and development ofstomata.

13. What is Krantz anatomy? Mention its significance.
14. Write a brief note on the following:

    (a) Apomixis (b) Polyembryony (c) Xenia
15. What are the developmental changes in shoot apex leading to floral induction?
16. Write a brief note on different type of gardening.
17. What is meant by genetic drift?
18. What is pagoda?

(7 x 2 = 14)

Section C

Answer any **two** questions. Each question carries a weight of 5)

19. Describe the anatomy of a flower. Add a note on the significance of floral anatomy to taxonomy.
20. With suitable example and illustration describe various anomalous primary and secondary structure in the stem of angiosperms.
21. Write an essay on morphogenesis and organogenesis in plants.
22. Write an essay on olericulture.

(2 x 5 = 10)

M Sc Botany Degree (CSS) Examination

II Semester
Faculty of Science

PBT2CRT0222: CELL BIOLOGY, GENETICS AND PLANT BREEDING

Time: 3 hours **Max. Weight: 30**

Section A

(Answer any **eight** questions. Each question carries a weight of 1)

1. What is apoptosis?
2. Write a brief description on cell adhesion molecules.
3. What are the functions of telomere?
4. What is the genetic significance of the fact that gametes contain half the chromosome complement of somatic cells?
5. Differentiate between heterochromatin and euchromatin.
6. Explain the relationships between the following pairs of genetic terms:

(a) Genotype and phenotype (b) Gene and trait (c) Allele and gene (c) Gene and chromosome 7. What causes phenylketonuria?

8. What is dosage compensation?

(6 x 1 = 6)

Section B

(Answer any **Seven** questions. Each question carries a weight of 2)

9. Explain the causes of inbreeding depression?
10. Differentiate between vertical and horizontal resistance with example.

11. Draw the diagram of a bivalent chromosome and label the following parts: centromere, sister chromatids, nonsister chromatids, homologous chromosomes, and chiasma.
12. Describe the self-assembly and the dynamic structure of cytoskeletal filaments.
13. Describe the endosymbiont hypothesis on the origin of chloroplast and mitochondria.
14. Quoting suitable examples, explain genetic drift.
15. Write an account on tumor-suppressor genes.
16. Describe the structure and functions of glyoxysomes and peroxisomes.
17. Explain the concept, "Centres of origin."
18. Describe the methods used for breeding disease resistance in plants.

(7 x 2 = 14)

Section C

Answer any **two** questions. Each question carries a weight of 5)

19. Describe the chemical composition, structural organization and the dynamic nature of plant cell membrane.
20. What is Hardy-Weinberg equilibrium? Describe the conditions for Hardy-Weinberg equilibrium.
21. Write an account on the modern trends in plant breeding.
22. What are cell-cycle checkpoints? Describe the principal checkpoints in the cell cycle.

(2 x 5 = 10)

M Sc Botany Degree (CSS) Examination

II Semester
Faculty of Science

PBT2CRT0322: PLANT PHYSIOLOGY AND BIOCHEMISTRY

Time: 3 hours **Max. Weight: 30**

Section A

(Answer any **Six** questions. Each question carries a weight of 1)

1. Define the following;
(a) Km (b) pKa (c) Vmax (d) Kw
2. What are isozymes?
3. Derive Henderson-Hasselbalch equation
4. Classify monosaccharides based on the number of C atoms.
5. What is RQ? Give the RQ for different substrates
6. Given an account of the role of Gibberellins
7. What is the membrane potential and how is it generated?
8. What is the role of the antenna complex in the light-dependent reactions of photosynthesis?

(6 x 1 = 6)

Section B

(Answer any **seven** questions. Each question carries a weight of 2)

9. Explain the structure and function of leghemoglobin during nitrogen fixation?
10. Write note on ABC transporters?
11. Write a brief account on the different methods of regulation of enzyme activity
12. Describe the following terms which are related to protein structure;

(a) Quaternary structure (b) α-helix (c) Peptide unit (d) Hydrogen bonds

13. Describe buffer action citing suitable examples

14. Write brief descriptions on;

(a) Aquaporin (b) Active transport (c) Light harvesting complexes (d) Glycolysis

15. Explain the mechanism of electron and proton transport in the thylakoid membrane

16. Write an account on soil-plant-atmosphere continuum.

17. Explain the rotenone-insensitive pathway in plants.

18. Describe the mechanism of entry of minerals into the roots of plants.

(7 x 2 = 14)

Section C

Answer any **two** questions. Each question carries a weight of 5)

19. What is Ramachandran plot? Describe the structural details and principles based on which Ramachandran plots are constructed. Add a note on its applications.

20. With the help of a diagram, describe the detailed structure of ATPase complex. Write the binding change mechanism of ATP synthesis.

21. What are the stresses to which plants are commonly exposed? Describe the stress tolerance mechanisms found in plants.

22. Compare and contrast between C3 and C4 photosynthesis.

(2 x 5 = 10)

M Sc Botany Degree (CSS) Examination

II Semester
Faculty of Science

PBT2CRT0422: MOLECULAR BIOLOGY

(2022 onwards)

Time: 3 hours **Max. Weight: 30**

Section A

(Answer any **six** questions. Each question carries a weight of 1)

1. In what sense does attenuation provide a "fine tuning" mechanism for operons that control amino acid biosynthesis?
2. Describe the function and importance of the 3' to 5' exonuclease activity of DNA polymerases
3. Explain the opposite polarity of the double stranded DNA.
4. What is SRP?
5. What is ARS?

(a) 6. What is histone code?

7. Explain the function of translation polymerase.
8. Comment on the role of chaperones in protein assembly.

(6 x 1 = 6)

Section B

(Answer any **seven** questions. Each question carries a weight of 2)

9. Explain the role of the following enzymes/proteins;

a)Rho protein (b) Sigma factor (c) Gyrase (d) Tus protein

10. 'Ribosome is a ribozyme'. Comment.
11. Describe the experimental methods used to crack the complete genetic code.
12. Describe the phenomenon of RNAi? How is RNAi involved in gene regulation?

13. Describe the genetic control of the entry of a Lambda phage into lytic or lysogenic growth.
14. Write briefly on the following;

(a) Shine-Dalgarno sequence (b) Kozak sequence (c) Amber codons (d) DNA quadruplex

15. What are transposons? Write a brief account on the types of transposons.
16. Write a brief account on ribozymes.
17. What are the functions of miRNA?
18. Describe how telomerase help maintain the structure of telomere.

(7 x 2 = 14)

Section C

Answer any **two** questions. Each question carries a weight of 5)

19. Describe the various modifications that the eukaryotic pre-mRNA usually undergoes.
20. Compare the following;

(a) Eukaryotic and prokaryotic promoters (b) Eukaryotic and prokaryotic Ribosomes (c) Eukaryotic and prokaryotic RNA polymerases (d) Eukaryotic and prokaryotic DNA polymerases

21. Write a comparative account of the molecular events taking place in the 5' – 3' synthesis of RNA during transcription and the 5' – 3' synthesis of DNA during the replication of DNA.
22. Describe the different methods of control of gene expression in eukaryotes.

(2 x 5 = 10)

MODEL QUESTION PAPERS – PRACTICAL

SEMESTER II - PRACTICAL COURSE I

PBT2CRP0122: PLANT ANATOMY, DEVELOPMENTAL BIOLOGY, HORTICULTURE, CELL BIOLOGY, GENETICS AND PLANT BREEDING

Time: 4 hours **Weightage: 15**

1. Make suitable micropreparation of specimen A. Draw diagrams, identify giving reasons.
(Total weight 1.5 = Preparation – 0.5, Identification with reasons – 0.5, Diagram – 0.5)
2. Describe and compare the stomatal type in the materials B and C.
(Total weight 1.5 = Identification of stomatal types with labeled diagram and reasons – 0.5 x 2, Comparison – 0.5)
3. Describe the nodal features of the material D.
(Total weight 1 = Identification of nodal type – 0.5, Description with diagrammatic sketch – 0.5)
4. Dissect embryo from the given seeds E.
(Weight 1= Preparation 0.5; Diagram 0.5)
5. Write critical notes on F.
(Weight 1= Correct identification with critical note)
6. Submit a potted plant G in which _____ grafting/layering has been carried out.
(Weight 1= Procedure with diagram 0.5, plant submitted 0.5)
7. Prepare a smear of the given anther H and identify any two stages of meiosis I.
(Total weight 1.5 = Preparation – 0.5, Identification with reasons – 0.5, Diagram – 0.5; 1.5 x 2 = 3)
8. Workout the problems I and J.
(Weight 1 = 1 x 2 = 2)
9. Estimate pollen sterility in the given sample K.
(Total weight 1 = Working – 0.5, Calculation – 0.5)
10. Practical record
(Weight 2)

Key to the questions:
1. A – Stem showing anomalous secondary growth, prescribed in the syllabus.
2. B, C – Leaves having distinct types of stomata
3. D - Nodal segments having type of node specified in the syllabus
4. E - Seeds with young embryos – maximum credit for globular stages
5. F - Permanent slide/Photograph of embryo types, polyembryony, endosperm types, pollen grains, anther developmental stages, types of ovules etc.
6. G – Whip and Tongue, Approach, Wedge, bud grafting and air layering.
7. H - Supply fresh flower buds of *Rhoeo* or *Chlorophytum.*
8. I, J - Problems related to Linkage mapping and population genetics.
9. K – Germination method
10. Awarding 'A grade' for the record of practical work shall be considered only if all the practical works specified in the syllabus are done completely and recorded properly. This also includes field study report(s)/Lab visit report(s), if any.

SEMESTER II - PRACTICAL COURSE II

PBT2CRP0222: PLANT PHYSIOLOGY, BIOCHEMISTRY AND MOLECULAR BIOLOGY

Time: 4 hours **Weightage: 15**

1. Conduct the experiment A
(Total weight 5 = Aim and principle - 1, Requirement and procedure -1, Working – 2, Result – 0.5, Comments/Interpretation – 0.5)
2. (a) Assay of total amylase enzyme from germinating seeds/Appropriate plant material B.
Or
(b) Estimate the amount of protein in the given sample B using Lowry's method
(Total weight 4 = Principle, requirements and procedure – 1.5, Working – 1.5, Calculation and result – 1)
3. Comment on C and D.
(Total weight 0.5 x 2 = 1)
4. Work out problems E and F.
(Weight 1.5 x 2 = 3)
5. Practical record
(Weight 2)

Key to the questions:
1. A – Draw lots from the list of physiology experiments provided. A minimum of 5 experiments from the list should be included in the lots.
2. B – Amylase/Protein. Students are expected to do the complete experiment using standard graph, preparation of extract on their own. Give the tissue, sample and reagents necessary.
3. C, D – Reagents, Chemicals
4. E, F – Problems related to DNA structure/replication/gene expression/genetic code. Students are allowed to bring a copy of genetic code chart showing codons and corresponding amino acids.
5. Awarding 'A grade' for the record of practical work shall be considered only if all the practical works specified in the syllabus are done completely and recorded properly. This also includes field study report(s)/Lab visit report(s), if any.

List of plant physiology experiments (Question 1)
1. Separate pigments of the given leaf sample by column chromatography. Collect the pigment fragments and submit. Comment on the result.
2. Separate amino acids by TLC and identify _____
3. Determine the osmotic potential of the given plant tissue from the values corresponding to change in weight of the tissue. Comment on the result.
4. Estimate the proline content in the control (e.g., seeds germinated in fresh water) as well as the treated sample (e.g., seeds germinated in 50mM NaCl). Comment on the result.
5. Estimate the phenol content in plant tissues affected by biotic stress and compare the same with non affected portions. Comment on the result.
6. Determine peroxidase activity in plant tissues affected by biotic/abiotic stresses. Comment on the result.

7. Estimate free amino acids in senescing leaves and compare the same with young leaves. Comment on the result.
8. Estimate the total chlorophyll in shade leaves and sun leaves and comment on the result
9. Estimate the leghaemoglobin in the root nodules

Detailed Syllabus: Semester III

Course Code	Name of the Course
PBT3CRT0122	Research Methodology, Phytochemistry, Biostatistics and Biological Techniques
PBT3CRT0222	Biotechnology, Bioinformatics and Bionanotechnology
PBT3CRT0322	Angiosperm Taxonomy, Economic Botany and Ethnobotany
PBT3CRT0422	Environmental Sciences
PBT3CRP0122	Research Methodology, Phytochemistry, Biostatistics, Biological Techniques + Biotechnology, Bioinformatics and Bionanotechnology (PRACTICAL)
PBT3CRP0222	Angiosperm Taxonomy, Economic Botany and Ethnobotany + Environmental Science (PRACTICAL)

Total credits: 19

Total hours: 450

COURSE-1: - RESEARCH METHODOLOGY, PHYTOCHEMISTRY, BIOSTATISTICS AND BIOLOGICAL TECHNIQUES (PBT3CRT0122)

No. of Credits- 4

No. of Contact Hours: Theory 18+ 18+18+18= 72 Hours; Practicals 09+27+09+18=63 Hours)

Course Overview and Context:

The course provides a deep knowledge regarding the planning, designing and execution of research. The course is designed to enhance the student's ability to identify, analyse and select

various research sources and adopt a proper methodology for the future research programmes as well as for project work. The statistical component of the course will enable the student to get deep insights on statistical tools and instrumentation for the conduct and execution of research experiments and interpretation of results.

Course objectives and outcomes:

- Develop a sense of inquiry to see research as a career and to take up a particular problem or concern to their scientific analysis.
- Demonstrate the capacity of in-depth analysis of information and creation of space for generating new questions, concepts and understandings.
- Describe and apply the principles and techniques of microtechnique in the preparation of temporary and permanent microscopic slides.
- Demonstrate competency in working with microscopes, chromatography, electrophoresis and spectroscopy.
- Analyse data using various tests of significance

PBT3CRT0122: RESEARCH METHODOLOGY, PHYTOCHEMISTRY, BIOSTATISTICS AND BIOLOGICAL TECHNIQUES

(Theory: 18+18+18+18= 72 Hours; Practicals: 09+27+09+18 = 63Hours)

Credits: 4

RESEARCH METHODOLOGY (Theory 18 Hours)

Module 1: Introduction (3 Hours)

Need for research, objectives of research, types of research, stages of research; generation of a research problem, execution of work; interpretation of results: Analysis of data, interpretation and conclusions. Research ethics. Intellectual property rights (IPR): Copy right and patenting- *Briefaccount*.

Module 2: Review of literature (6 Hours)

Library: Structure of a Scientific Library, Journals (Current and Back-volumes), Books.

Catalogue: Types of catalogues- card catalogue, computerized catalogue.Classification of books (Universal decimal system). Journals: indexing journals, abstracting journals, research journals, review journals, e- journals. Impact factor of journals; h-Index; NCBI, PubMed, Medline. Other sources of references: reprints-acquisition and filing. Internet, open access initiative, INFLIBNET, INSDOC, N-list and Shodhganga. Preparation of index cards: author index and subject index. Open source bibliography. Management system, citation management tools (*E.g.Mendeley*, *EndNot*).

Module 3: Preparation of project report and Dissertation/Thesis (3 Hours)

Project report. Dissertation/Thesis: Selection of problem and its relevance; available information collected; Execution of experimental programmes; Writing dissertation (*IMRAD System*): General Format; General principles in writing: Preliminary pages - title page, certificates, acknowledgements, and contents page. Main text of the Dissertation/Thesis: title, introduction, review of literature, material(s) and method(s), heading(s), result(s): table(s) and illustration(s), marginal indicator(s), caption(s), camera ready copy; discussion, summary and conclusion; references, abstract(s) and appendix.

Module 4: Preparation of Project Proposals, Presentation and Publication of Research Outcomes (6 Hours)

(a) Preparation of project proposal: title, introduction, literature review and abstract; aim and scope; present status; location of experiments; materials and methods; justification; expected outcome; date of commencement; estimated date of completion; estimated cost; references; funding agencies.

(b) Presentation and publication of research outcomes:

(i) Statistical analysis by using software (*Eg: - SPSS*). (ii) Preparation of research paper and short communications.(iii) Preparation of review articles.(iv) Proofreading-standard abbreviations for proof correction. (v) Presentation of Research findings in Seminars and Workshops.

Practical (9 Hours)

1. Visit a scientific library or documentation centre and submit a report.
2. Prepare a project proposal.

3. Prepare an outline of dissertation and research paper.
4. Prepare a list of references.

References

- Anderson J., Durston B. H. and Poole (1970). *Thesis and assignment writing*. Wiley eastern.
- Bedekar V. H. (1982). *How to write assignment and research papers, dissertations andthesis*.
- Bercy R. (1994). *The research project, how to write it*. Rutledge, London.
- Clifford Hawkins and Marco Sorghi. *Research: How to plan and speak about it and write about it*. Narosa Publishing Company.
- Day R. A. (1979). *How to write and publish a scientific paper*. Cambridge University press.
- Joseph Gibaldi (2000 & 2009). *MLA- Handbook for writers of research papers*. Affiliated East-West Press Pvt.Ltd, New Delhi.
- Judith Bell. *How to complete your research project successfully*. UBS Publishers and Kanak publications.
- Krishnakumar K. (1981). *An introduction to cataloguing practice*. Vikas Publishing house.
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- Victoria E. McMillan (1997). *Writing papers in the biological sciences* (II Edn). Bedford books.
- Vijay Upadhaya and Arvind Shende (2014). *Research methodology*. S. Chand and Company Pvt.Ltd. New Delhi.

PHYTOCHEMISTRY (Theory: 18 Hours)

Module 1 (3 hours)

Phytochemistry: Classification, history and scope of Phytochemistry. Recent advances in the field of chemical taxonomy. Phytochemical approach to economic botany. Plants in Medicine: Indigenous traditional drugs, traditional system of medicine, herbal medicine, folk medicine, unani and siddha medicine, ayurveda medicine and ethnopharmacology.

Module 2 (8 hours)

Plant Secondary Metabolites: Classification, structure and function of medicinally important plant products : glycosides, tannins, resins, oleoresins, volatile oils, alkaloids, carbohydrates, vitamins, proteins, fats, oils and waxes, phenolic compounds, plant acids, saponins, terpenoids, steroids, flavanols and flavones, betalins, pigments, dyes, gums and mucilage.

Module 3 (7 hours)

Essential Oils and Perfumery chemicals: occurrence, function, classification, structure, extraction and isolation techniques and essential oil analysis. Steam distillation, hydro distillation, solvent extraction, super critical fluid extraction. Application of essential oils – insecticides and perfumery products, uses and storage of essential oils and perfumery chemicals. Histochemical localization of starch, lipid and lignin. Flavouring agents. Aromatherapy.

PRACTICALS: 27 hours

1. Histochemical analysis of plant components.
2. Estimation of water content, dry matter, ash content, total free amino acids, total proteins, total carbohydrates, free fatty acids, vitamins, pigments, tannins and alkaloids.
3. Determination of acid value, iodine value and saponification value of oils.
4. The students will have to attend an internship in Phytochemical techniques accompanied by a faculty member at a reputed organisation/ institute for hands-on training.

References

- Arumugam K R and Murugesh (2005) Textbook of Pharmacognosy. Sathya Publishers, Madurai.
- Atul Shirkhedkar and Surana S J (2008) Pharmacognosy and Phytochemistry. Pragathi Books Pvt. Ltd
- Bhatia S C (1983) Essential Oils and Perfumery Chemicals. Shree Publishing House, Delhi.

- Biren N Shah and Seth A K (2014) Textbook of Pharmacognosy and Phytochemistry. Elsevier Science Publishing Company. Inc
- Daniel Mammen (1991) Methods in Plant Chemistry and Economic Botany. Kalyani Publishers, New Delhi.
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- Warier P K, Nambiar V P K and Ramamurthy C (1994) Indian Medicinal Plants Vol. I – V. Orient Longman Ltd.

BIOSTATISTICS (Theory: 18 Hours)

Module 1: Introduction to Statistics (4 Hours)

Basic principles and methods of Biostatistics: data collection, Primary and Secondary data. Tools for data collection and presentation. Measures of central tendency and dispersion.

Module 2: Probability, Correlation and Regression (5 Hours)

Probability - Definition, Mutually exclusive and Independent events. Binomial and Normal - distribution.Linear Regression and Correlation (*Simple and Multiple*).

Module 3: Design of experiments (4 Hours)

Experimental Designs: Principles -Replication, Randomization and Local control. Common designs in Biological experiments: Completely Randomized Design (CRD), Randomized Block Design (RBD), Latin Square Design (LSD), Factorial Design (FD).

Module 4: Tests of Significance (5 Hours)

Statistical Inference-Estimation-Testing of Hypothesis: - t-Test, Chi-square Test (Goodness of fit, Independence or Association, Detection of Linkages), F-test, ANOVA.

Practical (9 Hours)

1. Test the significance of a given data using t-Test, Chi square -test.
2. Analysis of a set of data for Correlation / Regression (Scatter diagram).
3. Determine the probability for different types of events.

References

- Chandel R. S. (1975). *A handbook of Agricultural statistics*. Achal prakashan Mandir.
- Gomez K. A. and Gomez A. A. (1984). *Statistical procedures for agricultnduralresearch*. John Wiley and sons.
- Gupta S. P. (1984). *Statistical methods*. S Chand and company. New Delhi.
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Council of Agricultural Research, New Delhi.

- Robert J. Brooker (2009). *Genetics: analysis & principles* (III Edn). McGraw Hill.
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- Thomas M. Little and F. Jackson Hills (1978). *Agricultural Experimentation*. Johnwiley and sons, Newyork.

BIOLOGICAL TECHNIQUES (Theory 18 Hours)

Module 1: Microscopy (2 Hours)

Principles of Microscopy; Stereo Microscope, Phase contrast Microscope, Fluorescence Microscope. Electron Microscopy (Eg: TEM, SEM, and E-SEM-*Brief account*).

Module 2: Principles and Applications of Instruments (5 Hours)

Micrometry. Basic principles and applications of UV–Visible spectrophotometer and centrifuges (E.g. Table top and ultracentrifuge). Flow cytometry. Immunoassay system-RIA and ELISA.Cryobiology- Lyophilisation and its applications. Auto radiography and Liquid Scintillation counter.

Module 3: Separation and Analytical Techniques (3 Hours)

Types of Chromatography**:** Column chromatography, ion exchange chromatography, GCMS, HPLC, HPTLC and LCMS. Separation and analytical techniques

Module 4: Basic principles and applications of Electrophoresis and Spectroscopy (5 Hours)

Electrophoresis: Agarose gel Electrophoresis, SDS PAGE, Pulse Field Gel Electrophoresis. Fluorescence, UV, IR, ORD, Visible, NMR, ESR, and Atomic Absorption.

Module 5: Serial sectioning (3hrs)

Serial Sectioning: Microtome, Paraffin embedding, serial sectioning and mounting

Practical (18 Hours)

1. Separation of molecules using HPLC (Demonstration only)

2. Preparation of paraffin blocks and serial sections.
3. Estimate the concentration of the given sample using colorimeter or spectrophotometer.
4. Separation of Plant pigments using column chromatography.

References

- Ackerman E A, Ellis L E E, Williams L E (1979). *Biophysical Science*. Prentice-Hall Inc.
- Chang R (1971). *Basic principles of spectroscopy*. McGraw Hill.
- Pesce A J, Rosen C G, Pasty T L. *Fluorescence Spectroscopy: An introduction forBiology and Medicine*. Marcel Dakar.
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- Mahadevan A, Sridhar R (1996). *Methods in Physiological Plant Pathology*. Sivakmi Publications.
- Salle A J (1974). *Fundamental principles of Bacteriology*. McGraw Hill.

COURSE-2: BIOTECHNOLOGY, BIOINFORMATICS AND BIONANOTECHNOLOGY (PBT3CRT0222)

No. of Credits- 4

No. of Contact Hours: Theory 72 Hours; Practicals 36 Hours)

Course Overview and Context:

The programme and the course provides a sound and firm foundation in the principles underlying modern biotechnology techniques including plant tissue culture, cloning for expression of desired genes and its integration, a sound theoretical understanding with training in bioinstrumentation and

bioinformatic tools that find application in biotechnological areas. The course is designed to enhance the student's ability to contribute to the development of scientifically just, ethical and culturally sensitive solutions incorporating biotechnology to solve complex problems for the economic upliftment of the society.

Course objectives and outcomes:

- Demonstrate the skill in planning and executing microbial biotechnology-based research.
- Apply the knowledge of various tools and techniques of recombinant DNA technology.
- Develop skill in plant tissue culture techniques which finds application in the agricultural, medical and environmental sectors.
- Apply the knowledge of bioinformatics softwares for revealing various facts about living organisms.
- Analyse the various aspects of nanotechnology and its applications in problem solving

PBT3CRT0222: BIOTECHNOLOGY, BIOINFORMATICS AND BIONANOTECHNOLOGY

(Theory 72 Hours; Practical 36 Hours; Credits: 4)

BIOTECHNOLOGY (54 Hours)

Module 1: Bioprocess Technology (5 Hours)

(a) Introduction to classical and modern biotechnology. Microbial biotechnology**:** Mode of operation of a bioprocess – basic concepts of batch, fed batch and continuous operation of a bioprocess.

(b) Basic design and construction of various types of bioreactors used in bioprocesses.

(c) Commercialproduction of metabolites using bioreactors. Submerged and solid state fermentation. Microbes in production of enzymes, antibiotics, biopolymers, bioethanol, organic acids, SCP.

Module 2: Plant tissue culture (12 Hours)

(a) Brief history and important milestones in plant tissue culture. Types of cultures: organized structures - meristem, shoot tip, node, embryo, root cultures; unorganized structures - callus,

suspension and protoplast cultures. Cellular totipotency. Differentiation of cells in callus - tracheid formation, chloroplast differentiation. Factors influencing vascular differentiation. Organogenic and embryogenic differentiation.

(b) Culture protocol: General composition of the culture media; solid and liquid media – gelling agents. Preparation and standardization of MS medium for shoot and root differentiation. Sterlization of medium, glasswares, instruments, plant material, transfer area. Preparation of explants and inoculation, incubation. Pattern of growth and development, subculturing.

(c) Micropropagation: Methods – shoot tip and nodal segment culture, stages of micropropagation. Advantages and disadvantages of micropropagation. Applications of tissue culture.

Module 3: Genetic engineering (15 Hours)

(a) Important steps in Gene cloning:Basic principles of gene cloning.Isolation and purification of DNA from cells (Brief study). Isolation of DNA fragments of interest, creation of recombinant DNA – introduction into host cells, selection and screening of recombinants, propagation of recombinants.

(b) Tools and techniques: Restriction endonucleases, Ligases. Vectors – necessary properties of a vector, types of vectors based on origin; shuttle vectors, expression vectors.

(c) Plant transformation**:** *Agrobacterium tumefaciens* mediated gene transfer in plants - details of vector system based on *A. tumefaciens*, binary vector and cointegrate vector. Steps involved in *Agrobacterium* mediated gene transfer to plants. Plant transformation by direct transfer of DNA (Vectorless methods) - microprojectiles, electroporation, microinjection, chemical, lipofection.

(d) Applications of genetic engineering -in genetic studies, agriculture, and medicine (brief study citing specific examples)

Module 4: Genome editing (3 Hours)

Introduction, scope, methods and applications

Module 5: Advanced tools and techniques in Biotechnology (10 Hours)

(a) cDNA synthesis, artificial DNA synthesis – solid-phase synthesis.

(b) PCR - Procedure and applications, variants of PCR - Real time PCR and reverse transcriptase PCR and their applications.

(c) Automated DNA sequencing.

(d) *In vitro* mutagenesis, site directed mutagenesis.

(e) Blotting techniques - procedure and applications of southern, northern, western, and dot blotting. Microarray (gene chip) technology and its applications.

(f) Procedure and applications of DNA profiling, Footprinting.

(g) Procedure and applications of FISH and GISH

Module 6: Genomics (5 Hours)

Introduction to genome, genomics, transcriptomics and proteomics. Structural genomics - genome sequencing strategies. Genome annotation – structural and functional annotation, gene expression study using microarrays.

Module 7: Societal concerns with biotechnology (4 Hours)

Harm to the environment - potential impact of GMOs on the ecosystem; GM food – effect on health and environment. Misuse of modern molecular biology tools and techniques, bioweapons, bioterrorism. Ethical issues relating to rDNA techniques. Patents – issues relating to patenting living organisms, their genes and other bioresources.

BIOINFORMATICS (12 Hours)

Module 1: Methods, tools and applications of bioinformatics (6 Hours)

(a) Databases: Organization, primary and secondary databases. DNA sequence databases - Genbank, EMBL & DDBJ. Protein databases - SWISS-PROT, PDB.

(b) Sequence alignment: significance; global alignment, pair wise analysis, scoring matrices (an introduction). Database similarity search – query sequence search; BLAST – Algorithm and different versions. FASTA. Multiple sequence analysis, dynamic programming.

Module 2: Molecular phylogeny (3 hrs)

Introduction, molecular clock hypothesis. Phylogenetic trees, terminology in phylogenetic tree. Tree drawing methods. Cladogram and Phylogram. Significance of molecular phylogeny.

Module 3: Structural bioinformatics (3 hrs)

Introduction, molecular structure viewing tool – Rasmol; Protein structure prediction – secondary structure prediction (Chou Fasman method), tertiary structure prediction (Homology modeling)

BIONANOTECHNOLOGY (6 Hours)

Module 1: Introduction to nanoparticles and nanotechnology (3 Hours)

(a) An overview on concepts, strategies and tools. Types of nanoparticles and their relative merits and demerits.

(b) Method of biological synthesis of Zn and Ag nanoparticles – plant extract, bacteria and fungi.

Module 2: Applications of Bionanotechnology (3 Hours)

Use of nanoparticles in agriculture, medicine and environment. Impact of NPs on germination and seedling emergence, parameters in various crops. Effect of NPs on gene expression. Translocation and accumulation of NPs in plant tissues and organs.

Practical (36 Hours)

1. Production of amylase by solid state and submerged fermentation.
2. Preparation of the stock solutions of MS medium and preparation of MS medium from stock solutions.
3. Isolation, preparation, sterilization and inoculation of different explants like shoot tip, node, anther, embryo and cambium.
4. DNA isolation from coconut/onion/cauliflower and separation using agarose gel.
5. Blast search with Protein Sequence (*Magnolia latahensis* sequence)
6. Blast search with Nucleic Acid Sequence (Neanderthal man's Paleo DNA)
7. Phylogenetic tree creation with the help of CLUSTAL X, W or MUSCLE and tree drawing tools.
8. Creation of phylogenetic trees for selected families of Eudicots.
9. Molecular docking (using either free or commercial Software).

References

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- Benjamin A Pierce (2008). *Genetics: A conceptual approach* (IV Edn). W H Freeman and Company.
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COURSE-3: ANGIOSPERM TAXONOMY, ECONOMIC BOTANY AND ETHNOBOTANY (PBT3CRT0322)

No. of Credits- 4

No. of Contact Hours: Theory 72 Hours; Practicals 63 Hours)

Course Overview and Context:

This course enables the learner to study the morphology and taxonomy of Angiosperms along with their economic value and ethnobotanical importance. The different systems of classifications, concept of taxa, botanical nomenclature, and various families of Angiosperms as per Bentham and Hookers classification have been dealt with in detail. The modules also deal with the importance of economic botany including the important plantation crops of Kerala as well as the importance, sources and methods in ethnobotany, important tribal people of Kerala and plants used by them.

Course objectives and outcomes:

- Differentiate between the salient features of various angiosperms families.
- Identify the local flora using the Flora of the Presidency of Madras (J. S. Gamble).
- Apply knowledge to work out nomenclatural problems regarding priority and author citations.

- Analyse various data sources, tools of taxonomy and phylogeny of Angiosperms.
- Identify and utilise the economically important plants, and discuss the sources and methods of ethnobotanical studies

PBT3CRT0322: ANGIOSPERM TAXONOMY, ECONOMIC BOTANY AND ETHNOBOTANY

(Theory - 72 Hours; Practical - 63 Hours; Credits: 4)

Module 1: Introduction **(6 Hours)**

Scope and significance of taxonomy. Major classification systems with emphasis on conceptual basis of classifications of (i) Linnaeus (ii) Bentham & Hooker (iii) Engler & Prantl (iv) Bessey (v) APG (brief synoptic account – current views).

Module 2: Units of classification and Phylogeny of Angiosperms **(9 Hours)**

(a) Taxonomic hierarchy

(b) Concept of taxa: Concept of species: taxonomic, biological & phylogenic species. Concept of genus, family and infraspecific categories - subspecies, variety, forma.

(c) Phylogenetic terms: Premitive and advanced; Homology & Analogy; Parallelism and convergence; monophyly & polyphyly; phylogenetic tree(brief study).

(d) Numerical taxonomy and Cladistics – methodologies of study.

Module 3: Data sources of taxonomy (brief account): **(5 Hours)**

(a) Concept of character

(b) Sources of taxonomic characters: Anatomy, Cytology, Phytochemistry, Molecular Taxonomy, DNA barcoding.

Module 4: Methodology of Identification of plants **(9 Hours)**

(a) Usage of floras; Preparation of indented and bracketed keys

(b) Brief accounts on Flora of the British India, Flora of the Presidency of Madras, Hortus Malabaricus. Important Floras of Kerala

(c) Familiarization of Technical terms associated with the following: Habit, Habitat; Root, Stem, Leaf, Inflorescence; Bract & bracteoles; Flowers; Fruits and Seeds**.**

Module 5: **Tools of Taxonomy** **(3 Hours)**

Field study, Herbarium and Virtual herbarium, Important Botanical gardens; BSI; Botanical literature (Journals- print and online, Floras, Revisions, Monographs, Indices).

Module 6: Botanical Nomenclature (4 Hours)

(a) History of Botanical nomenclature and code

(b) Aims and principles of Botanical nomenclature

(c) Study of major provisions of the code (ICN): Typification; Author citation; rule of priority; Effective and valid publication – as per the current code; Retention, rejection and choice of names.

Module 7: Study of angiosperm diversity (27 Hours)

Study of following families with reference to tropical flora, as per Bentham and Hooker's concept in detail with economic importance of members:

1. Ranunculaceae 2. Magnoliaceae 3. Annonaceae 4. Polygalaceae 5. Caryophyllaceae 6. Clusiaceae 7. Malvaceae 8. Tiliaceae 9. Geraniaceae 10. Rutaceae 11. Vitaceae 12. Sapindaceae

13. Leguminosae 14. Myrtaceae 15.Melastomaceae 16. Lythraceae 17. Cucurbitaceae 18. Aizoaceae 19. Apiaceae 20. Rubiaceae 21. Asteraceae 22. Campanulaceae 23. Myrsinaceae 24. Sapotaceae 25. Oleaceae 26. Apocynaceae 27. Asclepiadaceae 28. Boraginaceae 29. Convolvulaceae 30. Solanaceae 31.Scrophulariaceae 32. Acanthaceae 33. Verbenaceae 34. Lamiaceae 35. Polygonaceae 36. Aristolochiaceae 37. Lauraceae 38. Euphorbiaceae 39.Orchidaceae 40. Zingiberaceae 41. Liliaceae 42. Araceae 43. Cyperaceae 44. Poaceae.

Module 8: Economic Botany (6 Hours)

(a) Importance of Economic Botany. Important Plantation crops of Kerala and brief study on their various products - Rubber, Cardamom, Tea, Coffee, Coconut, Catechu.

(b) Major food plants: **Cereals**: Rice, wheat, maize, oats. **Millets**: Sorghum, Pearl millet, Ragi, Italian millet. **Pulses**: Pigeon pea, Garden pea, Black gram, Green gram, Bengal gram. **Sugar**: Sugar cane. **Fruits**: Banana, Mango, Jackfruit, Apple, Pineapple, Orange, Lemon. **Vegetables**: All common vegetables used in traditional Kerala kitchen. **Oil plants**: Coconut, Ground nut, Gingelly. **Spices**: Cardamom, Pepper, Ginger, Clove, Cinnamon, Coriander, Fennel, Fenugreek. **Fibre:** Coir, Jute, Cotton.

(c) **Gums and Resins**: White Damar, Gum Arabic, Asafoetida.

(d) **Medicinal plants**: Liquorice, Indian Sarsaparilla, Chitraka(*Plumbago*), Serpentine, Aswagandha, Asafoetida, Greater galangal, Turmeric, Mango ginger, Garlic, Ginger, Asoka tree, Vasaka, Indian Aloe, Holy Basil, Bel, Betel, Pepper, Belleric Myrobalan, Chebulic myrobalan, Neem, Apple of Peru (*Datura*).

Module 9: Ethnobotany **(3 hours)**

Importance, sources and methods; important tribal people of Kerala; plants used by them such as *Trichopus zeylanicus, Ochlandra travancorica, Dendrocalamus strictus, Gloriosa superba, Emilia sonchifolia, Andrographis paniculata*.

Practical **(63 Hours)**

1. Work out a minimum of 2 members from each family with suitable sketches and description in technical terms of locally available plants. Record reasons assigned for Class, subclass, series/order, family and draw at least one species from each family in the record.
2. Identification of local flora using Flora of Presidency of Madras- J. S. Gamble.
3. Conduct study tour for not less than 5 days to study angiosperm diversity and collect plants from diverse habitats belonging to plant families specified above and also visit important botanical gardens and institutions of taxonomic research and submit a report.
4. Preparation of 25 herbarium specimens from the plant families of study and submit.
5. Study of preparation of dendrogram using a suitable software (of a family or Genus of study).
6. Workout nomenclatural problems regarding priority and author citations.
7. Familiarization of morphological terms form live specimens; specimens of economic botany from families of study.

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COURSE-4: ENVIRONMENTAL SCIENCE (PBT3CRT0422)

No. of Credits- 3

No. of Contact Hours: Theory 54 Hours; Practicals 27 Hours)

Course Overview and Context:

This course deals with the significance of ecosystems, environment and environmental factors and natural resources, their conservation and sustainable utilization. The impact of anthropological activities on environment and resources is one of the important focuses of the course. The

significance of biodiversity in maintaining the balance of Mother Earth and develop strategies for its conservation and proper management is very significant part of this course.

Course objectives and outcomes:

- Apply the concepts in population and community ecology towards creation of a better sense of environmental protection with good understanding on the dynamics of the Ecosystem.
- Conceive a good understanding on Biosphere and Ecosystem and able to predict the Phytogeographical variation
- Evaluate the anthropogenic/ natural causes leading to disaster and climatic changes
- Analyse global environmental problems and suggest its management strategies.
- Evaluate the values of biodiversity and reasons for biodiversity loss and suggest measures to conserve biodiversity

PBT3CRT0422: ENVIRONMENTAL SCIENCE

(Theory 54 Hours; Practical 27 Hours; Credits 3)

Module 1: Introduction to Ecological Science (2 Hours)

Definition, history and scope of ecology, Interdisciplinary nature of environmental sciences.

Module 2: Autecological concepts - Population Ecology (5 Hours)

(a) Characteristics of populations - size and density, dispersion, age structure, natality and mortality.

(b) Population growth - factors affecting population growth, environmental resistance, biotic potential, carrying capacity, positive and negative interaction, migration, subsistence density. Ecological consequence of overpopulations.

(c) Genecology - ecological amplitude, ecads, ecotypes, ecospecies, coenospecies.

Module 3: Synecological concepts - Community ecology (5 Hours)

(a) Ecological processes of community formation, ecotone, edge effect. Classification of communities - criteria of classification, dynamic system of classification by Clement.

(b) Special plant communities - quantitative, qualitative and synthetic characteristics of plant communities, coefficient of communities; Sorenson's Index of similarity.

(c) Dynamic community characteristics - cyclic replacement changes and non-cyclic replacement changes.

Module 4: Dynamic Ecology - Ecological succession (3 Hours)

(a) The concept, definition and reasons of succession. Classification of succession: Changes - autogenic and allogenic, primary and secondary, autotrophic and heterotrophic.

(b) Retrogressive changes or the concept of degradation, concept of climax or stable communities, resilience of communities.

Module 5: Biosphere and Ecosystem (7 Hours)

(a) Significance of habitat, biodiversity, ecological niche, trophic level, primary and secondary productivity, food chains, food webs, ecological pyramids, energy flow and nutrient cycles.

(b) Comparative study of the major tropical ecosystems: Tropical rain forests, Wetlands and tropical coastal ecosystems. Special emphasis to tropical coastal ecosystems: Conservation and management of tropical coastal ecosystems: The values of coastal ecosystems, issues of coastal ecosystems in the tropics, goals for conservation and management of tropical ecosystems: Providing for resilience, maintain/restore connectivity, protect water quality, conservation and recovery of Species-at-Risk, understanding the socio-economic context.

Module 6: Phytogeography (5 Hours)

(a) Definition, principles governing plant distribution, factors affecting plant distribution, theories of distribution, different types of distribution of vegetations on the earth, continuous and discontinuous distribution.

(b) Climate, vegetation and botanical zones of India.

(c) Remote sensing: Definition and data acquisition techniques. Application of remote sensing, geospatial variability and geotagging.

Module 7: Environmental pollution (10 Hours)

(a) Definition and classification.

(b) Water pollution: Water quality parameters and standards, different types of pollutants and their consequences. Types of water pollution, prevention and control - water shed management, waste water treatment. Waste water treatment with aquatic macrophytes.

(c) Air pollution: Air quality standards and index, ambient air monitoring using high volume air sampler, types and sources of air pollutants, air pollution and human health hazards, control of air pollution.

(d) Noise pollution.

(e) Radioactive and thermal pollution: Causes and hazardous effects, effective management.

Module 8: Environmental biotechnology and solid waste management (4 Hours)

Concept of waste, types and sources of solid wastes including e-waste. Bioremediation, Phytoremediation, bioaugmentation, biofilms, biofilters, bioscrubbers and trickling filters. Use of bioreactors in waste management.

Module 9: Global environmental problems and climate change (4 Hours)

(a) Global warming, greenhouse gases, acid rain, ozone depletion. Holistic relationship between air water and land pollution.

(b) Factors responsible for climate change, *El-Nino* and *La Nina* phenomenon and its consequences.

(c) Effect of climate change on biogeography.

(d) Environmental laws, environmental monitoring and bio indicators, environmental safety provisions in Indian constitution, major environmental laws in India, ISO-14000.

(e) Disaster management; preparedness and planning

Module 10: Biodiversity and its conservation (9 hours)

(a) Biodiversity- definition, the number of known plants in the world (upto groups), current biodiversity loss - concept of endemism, rare, endangered and threatened species (RET), key stone species, IUCN account of biodiversity, red data book and hot spots, reasons to stop extinction, methods to save species.

(b) Principles of conservation - *ex-situ* and *in-situ* conservation techniques. Biodiversity conservation: Species diversity, community diversity, ecosystem diversity. Role of biotechnology in conservation of species.

(c) The natural longevity of species, rain forests as centres of diversity, ecological restoration

(d) Ecotourism - positive and negative impacts.

Practical (27 Hours)

1. Analysis of water quality for; (a) Dissolved CO_2 (b) Dissolved oxygen (c) COD (d) Total dissolved minerals (e) Quantitative estimation of dissolved chloride ions and dissolved sulphate (f) Total alkalinity.
2. Quantitative estimation of dissolved silicate, dissolved sulphate, nitrite and total alkalinity.
3. Physico-chemical analysis of soil: (a) Total water soluble mineral ions (b) estimation of soil organic carbon (Walkey and Black method).
4. Quantitative and qualitative community analysis. Carry out a project on species structure and the frequency, abundance, density of different species and similarity index of different communities in a natural system. Students must be able to explain the structure of vegetation from the given data on the above mentioned characteristics.
5. Phytoplankton counting using Sedgwick Rafter counter.
6. Field visit to natural ecosystem and identification of trophic levels, food webs and food chains, plant diversity (species and community) and submit a report.
7. Students should be aware of the common environmental problems, their consequences and possible solutions.

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MODEL QUESTION PAPERS – THEORY

M Sc Botany Degree (CSS) Examination

III Semester

Faculty of Science

PBT3CRT0122: RESEARCH METHODOLOGY, PHYTOCHEMISTRY, BIOSTATISTICS AND BIOLOGICAL TECHNIQUES

Time: 3 hours **Max. Weight: 30**

Section A

(Answer any **six** questions. Each question carries a weight of 1)

1. Describe the structure of scientific library.
2. Write a note on the scope of Phytochemistry.
3. Give brief account of different type of journals.
4. Describe Primary and Secondary data.
5. Describe quantitative and qualitative data.
6. Write the principle and use of Phase contrast microscope.
7. Why is a statistical test necessary to determine the exceptability of an observed set of data?
8. What are essential oils? Mention their significance.

(6 x 1 = 6)

Section B

(Answer any **seven** questions. Each question carries a weight of 2)

8. Explain the principle and working of colorimeter?
9. Explain different type of microtomes used in microtechnique.
11. Write an essay on literature survey and its importance in research.

12. What are the different stages of research?
13. Write note on permanent whole mount preparation.
14. Give an account on secondary metabolites.
15. Describe the principles of electron microscopy.
16. How chi-square test is used for the detection of linkages?
17. Describe the basic principles and applications of ELISA.
18. Write a short essay on electrophoresis.

(7 x 2 = 14)

Section C

(Answer any **two** questions. Each question carries a weight of 5)

19. Prepare a sample project proposal on environment problem for submission to UGC.
20. Describe various steps in making permanent serial sections.
21. Describe experimental designing used for different types of study.
22. Write an essay on different types of electron microscope.

(2 x 5 = 10)

M Sc Botany Degree (CSS) Examination

III Semester

Faculty of Science

PBT3CRT0222: ANGIOSPERM TAXONOMY, ECONOMIC BOTANY AND ETHNOBOTANY

Time: 3 hours **Max. Weight: 30**

Section A

(Answer any **six** questions. Each question carries a weight of 1)

1. Describe the primitive characters Magnoliaceae.
2. Explain the pliesiomorphic and apomorphic characters.
3. Write an account on androecium of Orchidaceae.
4. Write the binomials and families of the following:
   (a) Tea (b) Chinese Potato (c) Rose wood (d) Cane
5. With the suitable example describe the medicinal importants of Apocymaceae.
6. Give the family name and economic products of the following plants:
   (a) *Mentha arvelsis* (b) *Lagenaria vulgaris* (c) *Cymbopogon citratus* (d) *Foeniculum vulgare.*
7. What is herbarium? How is a herbarium labeled?
8. What is Ethnobotany?

(6 x 1 = 6)

Section B

(Answer any **seven** questions. Each question carries a weight of 2)

9. Give any two plant products used by tribals for stomach ache.
10. What is BSI? Write its functions.

11. Critically evaluate Engler and Prantl's system of classification.
12. Compare the families of Verbenaceae and Lamiaceae.
13. Explained different type of keys used for plant identification.
14. Write the economic importance of family Cucurbitaceae.
15. Explain the floral characters of Euphorbiaceae.
16. Comment on the systematic position and affinity of the following genera.

    (a) *Nyctanthes* (b) *Coleus* (c) *Luffa*
17. Describe the advanced floral characters in the families of Disciflorae.
18. Comment on the economic importance of the following:

    (a) *Saccharum officinarum* (b) *Dalbergia sissoo* (c) *Adhatoda vasica* (d) *Cinnamomum camphora* (7 x 2 = 14)

Section C

Answer any **two** questions. Each question carries a weight of 5)

19. Critically evaluate the system of classification of angiosperm by Hutchinson and compare it with Bentham & Hooker's classification.
20. Describe the floral features of Umbelliferae and Guttiferae.
21. Compare and vegetative and floral features of the families of Bicarpellatae and write a note on its evolutionary trends.
22. Critically evaluate the phonetic and cladistic approaches in plant systematics.

(2 x 5 = 10)

M Sc Botany Degree (CSS) Examination

III Semester

Faculty of Science

PBT3CRT0322: BIOTECHNOLOGY, BIOINFORMATICS AND BIONANOTECHNOLOGY

Time: 3 hours **Max. Weight: 30**

Section A

(Answer any **six** questions. Each question carries a weight of 1)

1. Differentiate between stirred tank and airlift bioreactors.
2. What is androgenesis?
3. What are the causes of somaclonal variation?
4. Name four industrial chemicals produced by using microbial activities. Write the names of the microorganisms involved in each.
5. What is enzyme engineering? What are the applications of it?
6. Briefly describe bioaugmentation.
7. How are triploids produced?
8. How do we produce stem cells?

(6 x 1 = 6)

Section B

(Answer any **seven** questions. Each question carries a weight of 2)

9. Describe the importance of using tissue culture in producing secondary metabolites.

10. Define the following;

(a) Totipotency (b) Synseeds (c) Haploids (d) Stem cells

11. Write an account on the procedure and applications of hairy root culture.
12. Giving suitable examples, discuss downstream processing.
13. What are cybrids? How are they produced? Discuss the use of cybrids in crop improvement programmes.
14. Citing suitable examples, discuss the importance of GMOs in bioremediation
15. Describe the procedure of plant protoplast isolation and purification.
16. Briefly describe the prospects and future of stem cell research.
17. What is germplasm? Describe the methods of germplasm conservation. Add a note on the importance of tissue culture as a method of germplasm conservation
18. Write an account on the methods and applications of cell immobilization.

(7 x 2 = 14)

Section C

Answer any **two** questions. Each question carries a weight of 5)

19. Describe the procedure and applications of;

(a) Cryopreservation (b) Protoplast culture (c) Microspore culture (d) Cellulase production

20. What is enzyme immobilization? Describe the steps involved and the potential applications. Add a note on enzyme engineering.
21. Write an essay on bioremediation.
22. Describe the various tissue culture techniques used to produce ploidy variants in plants.

(2 x 5 = 10)

M.Sc Botany Degree (C.S.S) Examination

III Semester

Faculty of Science

Course Code- PBT3CRT0422: Environmental Science

Time: Three hours Max. Weight: 30

Section- A

(Answer any **six** questions. Each question carries a weight of 1)

1. Define the scope of ecology.
2. What is biotic potential?
3. Describe ecads and ecotypes.
4. Define consociation and formation.
5. What is meant by resilience of communities?
6. What is smog?
7. Define phytoremediation.
8. Define key stone species.

(6 x 1 = 6)

Section B

(Answer any **seven** questions. Each question carries a weight of 2)

9. Define primary production. Explain any two methods of estimating primary productivity.
10. Describe discontinuous distribution with suitable example.
11. What is ecotone and edge effect?

12. What are wetlands, why are they known as *biological supermarkets* and *kidneys of landscapes?*
13. Describe the community classification by Clement.
14. Describe geospatial variability and geotagging.
15. Mention the factors affecting plant distribution
16. Comment on disaster management
17. Mention the causes and effects of radioactive pollution
18. Distinguish between *El-Nino* and *La Nina* phenomenon

(7x 2 = 14)

Section C

(Answer any **two** questions. Each question carries a weight of 5.)

19. Write an essay on global warming and its impacts.
20. Explain remote sensing and its applications.
21. Elaborate biodiversity and principles of conservation.
22. Illustrate tropical coastal ecosystems

(2 x 5 = 10)

MODEL QUESTION PAPERS – PRACTICAL

SEMESTER III - PRACTICAL COURSE I

PBT3CRP0122: RESEARCH METHODOLOGY, PHYTOCHEMISTRY, BIOSTATISTICS AND BIOLOGICAL TECHNIQUES AND BIOTECHNOLOGY, BIOINFORMATICS AND BIONANOTECHNOLOGY

Time: 4 hours **Weightage: 15**

1. Estimate the iodine value of oil from the sample provided.
(Total weight 3: Requirement and procedure- 1, Working -1.5, Result-0.5)
2. Prepare serial sections of B and mount on a glass slide
(Total weight 2: Microtome sectioning – 1.5, Mounting – 0.5)
3. Permanent slides
(Weight 1)
4. Workout problem C
(Weight 1)
5 Estimate the concentration of the plant sample using spectrophotometer.
(Total weight 1.5: Working -1, Result-0.5)
6. Prepare _____ ml liquid medium (MS) containing _____ µM Cytokinin and _____ µM Auxin. Write down the protocol for the same with calculations. Adjust the pH of the medium as specified.
(Total weight 2: Calculation and protocol – 1; Preparation - 1)
7. (a) Draw a phylogenetic tree using the gene sequence data file with the help of CLUSTAL X/W or MUSCLE and tree drawing tool
(Total Weight 2: MSA - 1; Phylogenetic tree - 1)
OR
(b) Blast search with the given protein sequence (e.g. *Magnolia latahensis* sequence)
(Total Weight 2: BLAST Search – 1; Downloading first 10 results - 1)
8. Viva voce based on the project proposal submitted by the student.
(Total weight 1: project proposal – 0.5; Viva – 0.5)
9. Practical record.
(Weight 2)

Key to the questions:
1. A – Oil for estimation
2. B – Supply embedded paraffin blocks, mounting the ribbon in a minimum of two rows.
3. Permanent slides prepared by the student as specified in the syllabus and certified by the head of the Department
4. C – Problem from Probability/Chi-square test/t-test.
5. Give necessary samples
6. Supply stock solutions necessary to prepare MS medium.

7. Centre should provide processed text file containing phylogenetically related gene sequences in FASTA format. Tools for MSA such as CLUSTAL and MUSCLE create output files. Such output files are the source files for the creation of Phylogenetic trees using tools like NJ Plot or Dendroscope

OR

Download protein sequences like Magnolia latahensis rbcL gene from genbank and save it in each desktop.

8. Submit a project proposal by each student; conduct a Viva voce based on it.

9. Awarding 'A grade' for the record of practical work shall be considered only if all the practical works specified in the syllabus are done completely and recorded properly. This also includes field study report(s)/Lab visit report(s), if any.

SEMESTER III - PRACTICAL COURSE II

PBT3CRP0222: ANGIOSPERM TAXONOMY, ECONOMIC BOTANY AND ENVIRONMENTAL SCIENCE

Time: 4 hours **Weightage: 15**

1. Identify the families of the given specimens A and B.
(Total weight 1.5: Identification of the series and cohort with reasons – 0.5; Identification of the family with reasons – 1; 1.5 x 2 = 3)
2. Identify the given material C up to genus.
(Total weight 1.5: Identification up to family with reasons – 0.5; Identification of genus with author citation and preparation of genus key – 1)
3. Identify the given material D up to species.
(Total weight 2.5: Identification up to family – 0.5; Identification of genus with author citation and genus key – 1; Identification of species with author citation and species key – 1)
4. Describe the given material E in technical terms. Draw L.S of the flower, floral diagram and write the floral formula.
(Total weight 1: Description of vegetative and floral characters – 0.5; LS, floral diagram and floral formula – 0.5)
5. Prepare an artificial key to identify the 4 specimens given, F, G, H, I.
(Weight 0.5)
6. Write the Economic/ethnobotanical importance of the materials J and K.
(Weight 0.5: 0.5 x 2 = 1)
7. Herbarium and field book.
(Weight 1)
8. Identification of herbarium specimens L and M.
(Total weight 0.5 x 2 = 1)
9. Quantify nitrite /silicate/sulphate in the given sample N using Spectrophotometer/ Colorimeter.
(Total weight 1.5: Procedure – 0.5; Working – 0.5; Result and comments – 0.5)
10. Practical record
(Weight 2)

Key to the questions:
1. A, B – Plant materials for family identification
2. C – Material for genus identification
3. D – Material for species identification
4. E - Give a plant twig complete with vegetative and floral features.
5. F, G, H, I – Supply appropriate specimens to prepare a key.
6. J, K - Raw or finished products of economically/ethnobotanically important plants
7. Herbarium (25 nos.) and field book certified by the head of the department and submitted by the student.
8. L, M - Write the binomials of the two herbarium specimens selected randomly by the examiner.
9. N - Supply suitable water samples
10. Awarding 'A grade' for the record of practical work shall be considered only if all the practical works specified in the syllabus are done completely and recorded properly. This also includes field study report(s)/Lab visit report(s), if any.

Detailed Syllabus: Semester IV

PROGRAMME ELECTIVE - BIOTECHNOLOGY

Course Code	Name of the Course	Teaching hours		Credits
		Theory	Practical	
PBT4CRT0122	Plant Tissue Culture and Microbial Biotechnology	90	72	4
PBT4CRT0222	Genetic Engineering, Genome Editing and Immunology	90	54	4
PBT4CRT0322	Genomics, Transcriptomics, Proteomics and Bioinformatics	90	54	4
PBT4CRP0122	Plant Tissue Culture and Microbial Biotechnology (PRACTICAL)			2
PBT4CRP0222	Genetic Engineering, Genome Editing, Immunology, Genomics, Transcriptomics, Proteomics & Bioinformatics (PRACTICAL)			2
PBT4CPR0122	Project Work			4
PBT4CRV0122	Viva-Voce			3

Total credits: 23

Total hours: 450

Course-1: Plant Tissue Culture and Microbial Biotechnology (PBT4CRT0122)

No. of Credits- 4

No. of Contact Hours: Theory 90 Hours; Practicals 72 Hours)

Course Overview and Context:

The programme and the course provides a sound and firm foundation in the principles underlying modern biotechnology techniques including plant tissue culture, cloning for expression of desired genes and its integration, a sound theoretical understanding with training in bioinstrumentation and bioinformatics tools that find application in biotechnological areas. The course is designed to enhance the student's ability to contribute to the development of scientifically just, ethical and culturally sensitive solutions incorporating biotechnology to solve complex problems for the economic upliftment of the society.

Course objectives and outcomes:

- Apply the principles of tissue culture in plant propagation.
- Demonstrate skills in isolation, purification and culture of protoplasts.
- Identify the techniques for conservation and preservation of germplasms.
- Evaluate the potential uses of various microbes in industrial production of materials/ processes.
- Explore the scope of microbes and plants in bio/phyto-remediation process for environmental health

PROGRAMME ELECTIVE - BIOTECHNOLOGY

PBT4CRT0122: PLANT TISSUE CULTURE AND MICROBIAL BIOTECHNOLOGY

(Theory 90 Hours; Practical 72 Hours; Credits 4)

Module 1: Tissue culture regeneration of plants (10 Hours)

(a) Adventitious shoot regeneration: Direct and indirect regeneration; factors influencing adventitious regeneration.

(b) Somatic embryogenesis: Direct and indirect, initiation of embryogenic cultures and regeneration of plants; factors regulating somatic embryogenesis. Synthetic seed production - protocol, types of synthetic seeds. Applications and limitations of synthetic seeds.

Module 2: Somaclonal variation **(8 Hours)**

Origin of somaclonal variation. Reasons for somaclonal variation – molecular basis. Applications of somaclonal variation.

Module 3: Embryo and meristem culture **(3 Hours)**

Methodology and applications.

Module 4: Protoplast culture **(8 Hours)**

(a) Isolation, purification and culture of protoplasts. Regeneration of plants from protoplasts. Significance of protoplast culture.

(b) Protoplast fusion (somatic hybridization) – chemical, mechanical, electrofusion. Isolation and selection of heterokaryons, regeneration and analysis of somatic hybrids; Cybrids. Applications of protoplast culture and somatic hybridization.

Module 5: Production of ploidy variants **(12 Hours)**

(a) Haploids: *In vitro* androgenesis- protocol for anther and microspore culture, advantages, applications. **Gynogenesis-** Developmental stage at inoculation, *in vitro* maturation of embryo sacs, origin of embryos, triggering factors- pretreatment, medium. Uses and limitations of haploid plants.

(c) Triploids: importance of triploid plants, conventional production of triploid plants, endosperm culture- advantages and limitations.

Module 6: *In vitro* germplasm conservation **(6 Hours)**

Importance of *in vitro* conservation. Short and medium term storage of germplasm, Cryopreservation technique – importance and methodology of cryopreservation. DNA banking for germplasm conservation.

Module 7: Production of secondary metabolites **(6 Hours)**

Culture conditions for producing secondary metabolites, selection of high yielding lines, elicitation. Hairy root culture – advantages of using hairy root culture, establishment of hairy root culture and production of secondary metabolites. Biotransformation.

Module 8: Cell and enzyme technology (5 Hours)

(a) Cell immobilization: Methods, advantages and applications.

(b) Enzyme immobilization: Methods and applications. Enzymes as biosensors. Enzyme engineering,

Module 9: Microbial technology (16 Hours)

(a) Screening of microbes for metabolite production- selection of media, strain improvement. Bioreactors- airlift, stirred tank, bubble column, rotary drum. Fermentation process- batch, fed batch, continuous fermentation. Process control during fermentation- pH, aeration, agitation, temperature, foam control. Downstream processing.

(b) Large scale production of antibiotics- penicillin, streptomycin; industrial chemicals- ethanol, acetone, citric acid; SCP- *Spirulina* and *Chlorella*; Biofertilizers- *Azotobacter* and *Rhizobium*; Bioinsecticides- *B. thuringeansis*, NPV. Commercial production of enzymes and their uses - amylase, cellulase, polygalacturonase.

Module 10: Tissue engineering and Stem cell technology (6 Hours)

Regenerative medicine, methods and applications of tissue engineering. Stem cells- embryonic stem cell and adult stem cells- production and applications.

Module 11: Bioremediation (10 Hours)

Importance and advantages of bioremediation, bioleaching, xenobiotics, organisms used for bioremediation. Cleaning strategies for water and soil- *in situ* and *ex situ* technologies. Bioremediation of radioactive wastes. Use of GMOs in bioremediation.

Practical (72 Hours)

1. Isolation of explants, establishment, subculture and maintenance of callus.
2. *In vitro* morphogenetic studies in any one plant system.
3. Study of the morphology of callus cells- callus smear preparation, histological aspects,

microtomy.

4. Isolation and fusion of plant protoplasts.
5. Preparation of synthetic seeds.
6. Preparation of selective medium for drought or salinity resistance. Preparation of MS medium from stock solutions containing auxin and cytokinin, NaCl or PEG, and inoculation.
7. Cell immobilization.
8. Application of immobilized yeast cells for ethanol production.
9. Isolation of microbes producing Organic acids/Enzymes.
10. Find out the uninucleate stage of pollen for anther culture.
11. Dissect out an embryo from any seed and culture it on a suitable solid medium.
12. Cell plating technique.

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Course-2: Genetic Engineering, Genome Editing and Immunology (PBT4CRT0222)

No. of Credits- 4

No. of Contact Hours: Theory 90 Hours; Practicals 54 Hours)

Course Overview and Context:

The present course provides a firm foundation in the principles underlying in modern genetic engineering and cloning techniques. The course also discusses the basic and applied aspects of genetic engineering and it gives an overview of recombinant DNA biosafety guidelines and regulatory mechanisms for their implementation.

Course objectives and outcomes:

- Explains various enzymes and ligation strategies used in gene cloning.
- Compare the unique features of different vectors and identify the suitable cloning strategy and screening technique for gene cloning experiments.
- Explains the construction of DNA libraries
- Explain and apply advanced recombinant DNA techniques in cutting-edge research.
- Describe the basic principles, techniques and strategies involved in immunology and their significance in our lives.

PROGRAMME ELECTIVE - BIOTECHNOLOGY

PBT4CRT0222: GENETIC ENGINEERING, GENOME EDITING AND IMMUNOLOGY

(Theory 90 Hours; Practical 54 Hours; Credits 4)

Module 1: Important tools and techniques in gene cloning (18 Hours)

(a) DNA cutting and modifying enzymes: restriction endonucleases- types, mode of action;alkaline phosphatase, polynucleotide kinase, S1 nuclease, exonucleases, Ligases.

(b) In vitro DNA ligation strategies: Joining with ligases–adaptors, linkers and homopolymertailing; topoisomerases, and site-specific recombinase.

(c) Vectors: Plasmid vectors, phage vectors and artificial chromosomes–BAC, YAC, PAC, HAC – important features, construction and applications of each.

(d) Cloning strategies: Genomic libraries, preparation of DNA fragments for cloning. Bacterial transformation, *in vitro* phage packaging and transfection.

(e) Selection and screening of recombinants: Insertional inactivation, complementation of defined mutation, microarray techniques, immunological screening for expressed genes. Reporter systems – *Lac Z* system, GFP.

Module 2: Gene library **(10 Hours)**

(a) Genomic and cDNA library. Procedure for the construction of a genomic library using phage λ system. Identification of desirable clones from library – hybridization probing, colony and plaque hybridization probing, immunological screening. Locating and isolating a gene - *in situ* hybridization, positional cloning, chromosome walking and jumping.

Module 3: Advanced transgenic technology **(6 Hours)**

Inducible expression systems – trtracycline expression system; site-specific recombination for *invivo* gene manipulation, gene targeting, gene silencing using antisense RNA and RNAi. RNAitherapy.

Module 4: Applications of rDNA technology **(10 Hours)**

(a) Uses of GM microbes: Bacteria and yeast– production of useful proteins, basic genetic research. Applications of GM animals: In basic research, producing novel proteins; disease studies, prevention and cure diseases.

(b) Uses of transgenic plants: Herbicide, insect and disease resistance, stress resistance. Genetic engineering for increasing nutritional and other novel qualities in plants, pharming.

Module 5: Genome editing **(12 Hours)**

(a) Process of genome editing: Basic principle and steps involved in genome editing.

(b) Genome editing methods: Meganucleases, ZFN, TALEN, CRISPR/Cas9.

(c) Applications of genome editing: Tool to study gene function, in genetic engineering, in gene therapy.

Module 6: Gene therapy **(8 Hours)**

Approaches to gene therapy- somatic cell and germline therapy, vectors used in gene therapy. *In vivo* and *ex vivo* therapy. Gene augmentation therapy. Problems and fears associated with gene therapy.

Module 7: Protein engineering (6 Hours)

Approaches to protein engineering- protein modification by site-directed mutagenesis, combinatorial methods. Applications of protein engineering.

Module 8: Biosensors (6 Hours)

Design and operation, types. Applications- medical, food and agriculture, industrial, pollution monitoring. GMOs as biosensors.

Module 9: Immunology (14 Hours)

(a) Innate and acquired immunity. Cells and molecules involved in innate and acquired immunity, humoral and cellular immunity, Antigens, Epitopes. Structure, function and types of antibody molecules.

(a) Generation of antibody diversity. Antigen-antibody interactions. Antigen processing and presentation. Activation and differentiation of B cells – formation, role. T cells – types, roles, T cell receptors. Primary and secondary immune modulation, complement system, pattern recognition receptors – toll-like receptors. MHC molecules. Cell-mediated effector functions, inflammation, hypersensitivity and autoimmunity, congenital and acquired immunodeficiencies.

(b) Production and uses of monoclonal antibodies, antibody engineering.

(c) Vaccines: Basic strategies, inactivated and live attenuated pathogens, subunit vaccines, recombinant vaccines (e.g., Hepatitis B vaccine), DNA vaccines. Modern approaches to vaccine development - edible vaccines.

Practical (54 Hours)

1. Identification of chemicals/reagents, tools, techniques, and procedures used in genetic engineering.
2. Work out problems based on restriction digestion of DNA, gel separation pattern etc.
3. Isolation of plant genomic DNA and its quantification.
4. Isolation of plasmids and its purification, by minipreparation and midipreparation.
5. Isolation of bacterial genomic DNA and its quantification by using UV spectrophotometer.
6. Separation of DNA by agarose gel electrophoresis.
7. Extraction and quantification of protein by Bradford method.
8. Separation of proteins by PAGE.

9. Conduct PCR.

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Course-3: Genomics, Transcriptomics, Proteomics and Bioinformatics (PBT4CRT0322)

No. of Credits- 4

No. of Contact Hours: Theory 90 Hours; Practicals 54 Hours)

Course Overview and Context:

The course aims to appraise the students to basic and high throughput techniques in Genomics and Proteomics and their applications. Advances in the technologies and informatics used to generate and process large biological data sets (omics data) are promoting a critical shift in the study of biomedical sciences. While genomics, transcriptomics and proteomics, coupled with bioinformatics and biostatistics, are gaining momentum, they are still, for the most part, assessed individually with distinct approaches generating monothematic rather than integrated knowledge. As other areas of biomedical sciences, including metabolomics, epigenomics and pharmacogenomics, are moving towards the omics scale, we are witnessing the rise of inter-disciplinary data integration strategies to support a better understanding of biological systems and eventually the development of successful precision medicine. It is therefore felt that this course will helps to target students and researchers seeking knowledge outside of their field of expertise and fosters a leap from the reductionist to the global-integrative analytical approach in research.

Course objectives and outcomes:

- Explain various methodologies in genome mapping and sequencing.
- Compare genome projects in different organisms
- Discuss the use of genomics and proteomics in human health.
- Apply concepts in bioinformatics for data analysis

- Develop a sense of ethics with regard to the procedures in genome analysis

PROGRAMME ELECTIVE - BIOTECHNOLOGY

PBT4CRT0322: GENOMICS, TRANSCRIPTOMICS, PROTEOMICS AND BIOINFORMATICS

(Theory 90 Hours; Practical 54 Hours; Credits 4)

Module 1: Genome mapping (12 Hours)

(a) Genome map – definition, types, and significance in genomics.

(b) Cytogenetic map – types (Brief study)

(c) Genetic mapping – basic principles for the construction of linkage maps. Markers for genetic mapping – genes, biochemical markers, molecular markers. Construction of linkage maps using molecular markers - RFLP, RAPD, AFLP, SSLP, SNP.

(d) Physical mapping – restriction mapping, STS mapping, EST.

Module 2: Genome sequencing (14 Hours)

(a) Basic steps in genome sequencing. Shot gun sequencing of small genomes. Hierarchical shot gun sequencing. Whole genome shot gun approach.

(b) Sequence assembly – methods used.

(c) Next generation sequencing strategies: Preparation of sequencing library. Reversible terminator sequencing (Illumina sequencing), Pyrrosequencing, 454 sequencing, ion torrent method, SOLiD. Third and Fourth generation sequencing.

(e) Important findings of the completed genome projects: Human genome project, Rice genome project, Arabidopsis genome project, *E. coli* genome project, Wheat genome project.

Module 3: Genome annotation (11 Hours)

(a) Structural annotation: by computer analysis of sequence data and experimental techniques

(b) Functional annotation: by computer based methods and experimental methods

Module 4: Comparative genomics (5 Hours)

Orthologs and Paralogs, gene identification by comparative genomics, comparative genomics as a tool in evolutionary studies. Metagenomics.

Module 5: Transcriptomics (5 Hours)

Components of the transcriptome. Methods of transcriptome analysis and its importance in genome annotation.

Module 4: Proteomics (8 Hours)

Proteome, proteomics. Protein profiling – steps in protein profiling. Protein sequencing. Protein expression analysis using protein microarray, protein localization using GFP.

Module 5: Bioinformatics (27 Hours)

(a) Internet and WWW. National Centre for Biotechnology Information – SRS. Computational Biology and Bioinformatics. Database organization and function. Types of databases based on the data storage pattern. Submission to and retrieval from databases – BankIt and sequin. Secondary Databases (PROSITE, PRINTS, BLOCKS).

(b) Sequence Analysis: Global Alignment, pairwise analysis, Scoring Matrices (an introduction), Database similarity search – query sequence search; BLAST – Algorithm and different versions; FASTA. Multiple Sequence Analysis dynamic programming for sequence alignment. Tools for multiple sequence alignment – CLUSTAL X/W.

(c) Structural Bioinformatics: Molecular Structure viewing tool – Rasmol; Protein structure prediction, secondary structure prediction - Chou Fasman method and other Bioinformatics tools for secondary structure prediction; Tertiary structure prediction - comparative modeling, Abinitio prediction, Homology modeling.

(d) Gene prediction strategies, ORF search, gene prediction programs – Grail/Exp, GENSCAN, ORF finder. RNA secondary structure prediction.

(e) Computer assisted drug design - concept, methods and practical approaches. Brief study about Docking tools, AutoDock, molegro virtual docker, GOLD.

(f) Applications of bioinformatics in evolutionary studies, molecular clock hypothesis. Molecular Phylogeny – Gene and Species tree. Molecular evolution and Kimuras theory, Phylogenetic Trees, Terminology in Phylogenetic tree. Tree drawing Methods. Cladogram and Phylogram, Significance of Molecular Phylogeny.

Module 6: Ethical, legal, and social impact of complete genome analysis (8 Hours)

Genome data availability – Problems with public availability of sequence data, privacy concerns, legal problems, gene and DNA sequence patenting, patenting transgenics.

Practical (54 Hours)

1. Work out problems based on genome mapping, sequencing gel pattern, gel separation pattern etc.
2. Blast search with Protein sequence (e.g. *Cytochrome C* sequence)
3. Blast search with Nucleic Acid Sequence (e.g *Magnolia latahensis* & Neanderthal man Paleo DNAs)
4. Carry out multiple sequence alignment using the given DNA sequences.
5. Phylogenetic tree creation with CLUSTAL X, W and MUSCLE and tree viewing tools. NJ Plot, Tree View, MEGA
6. Creation of phylogenetic trees for selected families of Eudicots
7. Molecular structure viewing - use of Rasmol (supply structure of a few proteins downloaded from PDB).
8. Locate specific sequences like TATA box, promoters, start signals, stop signals etc. in a DNA sequence using computer programmes e.g., *E. coli* promoter, human promoter.
9. Laboratory/Industry visit: Students are expected to conduct a visit to a sophisticated biotechnology laboratory/research centre/biotechnology industry to have an idea on the type of work going on there. A report of the visit should be prepared and submitted.

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MODEL QUESTION PAPERS - THEORY

M Sc Botany Degree (CSS) Examination

IV Semester

Faculty of Science

Programme Elective - Biotechnology

PBT4CRT0122**. PLANT TISSUE CULTURE AND MICROBIAL BIOTECHNOLOGY**

(2022 onwards)

Time: 3 hours **Max. Weight: 30**

Section A

(Answer any **six** questions. Each question carries a weight of 1)

1. Differentiate between stirred tank and airlift bioreactors.

2. Define the following;

(a) Totipotency (b) Synseeds (c) Haploids (d) Stem cells

3. What is androgenesis?

4. What are the causes of somaclonal variation?

5. Name four industrial chemicals produced by using microbial activities. Write the names of the microorganisms involved in each.

6. Briefly describe bioaugmentation.

7. How are triploids produced?

8. How do we produce stem cells?

(6 x 1 = 1)

Section B

(Answer any **seven** questions. Each question carries a weight of 2)

9. Describe the importance of using tissue culture in producing secondary metabolites

10. What is enzyme engineering? What are the applications of it?

11. Write an account on the procedure and applications of hairy root culture.

12. Giving suitable examples, discuss downstream processing.

13. What are cybrids? How are they produced? Discuss the use of cybrids in crop improvement programmes.

14. Citing suitable examples, discuss the importance of GMOs in bioremediation.

15. Describe the procedure of plant protoplast isolation and purification.

16. Briefly describe the prospects and future of stem cell research.

17. What is germplasm? Describe the methods of germplasm conservation. Add a note on the importance of tissue culture as a method of germplasm conservation.

18. Write an account on the methods and applications of cell immobilization.

(7 x 2 = 14)

Section C

Answer any **two** questions. Each question carries a weight of 5)

19. Describe the procedure and applications of;

(a) Cryopreservation (b) Protoplast culture (c) Microspore culture (d) Cellulase production

20. What is enzyme immobilization? Describe the steps involved and the potential applications. Add a note on enzyme engineering.

21. Write an essay on bioremediation.

22. Describe the various tissue culture techniques used to produce ploidy variants in plants.

(2 x 5 = 10)

M Sc Botany Degree (CSS) Examination

IV Semester

Faculty of Science

Programme Elective - Biotechnology

PBT4CRT0222**: GENETIC ENGINEERING, GENOME EDITING AND IMMUNOLOGY**

(2022 onwards)

Time: 3 hours **Max. Weight: 30**

Section A

(Answer any **six** questions. Each question carries a weight of 1)

1 Where does T DNA come from, and how is it used in making transgenic plants?

2. Name the key tools for accomplishing the tasks of recombinant DNA technology. Also mention the functions of each tool.

3. Explain the purpose of selectable marker genes in cloning experiments.

4. Explain how edible vaccines work?

5. Distinguish between genomic library and cDNA library

6. What are the advantages of Bt plants?

7. Write the important features in pUC.

8. What is antibody engineering?

(6 x 1 = 6)

Section B

(Answer any **seven** questions. Each question carries a weight of 2)

9. Explain what is meant by the following terms in relation to genetic engineering;

a)Transformation (b) Polylinkers (c) Lipofection (d) Expression

10. Comment on gene augmentation therapy.

11. Describe the following;

(a) BAC (b) DNA probes (c) Electroporation (d) TALEN

12. Highlight any four areas where genetic modification of plants has been useful.
13. What is a recombinant DNA vaccine? Give two examples
14. Explain the gene therapy strategy applied to treat a patient suffering from ADA deficiency.
15. You have identified a useful gene in bacteria. Make a flow chart of the steps that you would follow to transfer this gene to a plant.
16. Describe the important applications of Biosensors.
17. Describe the steps involved in the creation of a genomic library.
18. Comment on RNAi therapy.

(7 x 2 = 14)

Section C

Answer any **two** questions. Each question carries a weight of 5)

19. What is monoclonal antibody? How is monoclonal antibody produced in large scale? What are the uses of it?
20. Describe the following;

(a) Plaque hybridization (b) Biopharming (c) *In vitro* mutagenesis (d) Artificial chromosomes

21. 'Genes could be silenced using RNA'. Explain the methods used with examples.
22. Describe the methods and applications of genome editing.

(2 x 5 = 10)

M Sc Botany Degree (CSS) Examination

IV Semester

Faculty of Science

Programme Elective - Biotechnology

PBT4CRT0322**: GENOMICS, TRANSCRIPTOMICS, PROTEOMICS AND BIOINFORMATICS**

(2022 onwards)

Time: 3 hours **Max. Weight: 30**

Section A

(Answer any **six** questions. Each question carries a weight of 1)

1. What is multiple sequence alignment? Where is it useful?
2. What is a DNA marker? Give two examples.
3. Explain how some of the Restriction enzymes produce "sticky ends" while DNA is cut?
4. Write a brief note on metagenomics.
5. Explain the following terms related to drug design;

(a) GOLD (b) ORF (c) SOLiD (d) EST 6. What is STS?

7. How is GFP useful for protein localization in a living cell?
8. What is cladogram?

(6 x 1 = 6)

Section B

(Answer any **seven** questions. Each question carries a weight of 2)

9. What are secondary databases? Give examples.
10. Distinguish between a physical map and a genetic map.
11. Describe the major findings of HGP.
12. What is comparative genomics? How is it useful in determining the evolutionary relationships between organisms?

13. Explain the features of GENSCAN.
14. Explain the working and important features of BLAST?
15. What are the applications of genome sequencing?
16. Describe the following;

(a) Microarrays (b) Immunoprecipitation (c) Knock down mutants (d) SNP

17. Describe the different genome sequencing strategies
18. Describe the strategies adopted for sequence assembly.

(7 x 2 = 14)

Section C

Answer any **two** questions. Each question carries a weight of 5)

19. Describe the methods adopted for the annotation of the genome sequence.
20. Write an essay on the ethical, legal, and social issues generated by large-scale sequencing of genomes.
21. Explain the application of bioinformatics in evolutionary studies.
22. Write an essay on the different types of genome mapping techniques.

(2 x 5 = 10)

MODEL QUESTIONS – PRACTICAL

ELECTIVE – BIOTECHNOLOGY

SEMESTER IV - PRACTICAL COURSE I

PBT4CRP0122: PLANT TISSUE CULTURE AND MICROBIAL BIOTECHNOLOGY

Time: 4 hours **Weightage: 15**

1. Select and isolate amylase producing microbes from natural samples
(Total weight 3: Procedure – 1; Experiment – 1; Comment/Interpretation – 1)
2. Isolate early stage embryo from the given material in aseptic conditions and inoculate in the medium
(Total weight 2: Procedure – 1; Isolation and inoculation – 1)
3. Prepare synthetic seeds by inserting somatic embryo/zygotic embryo/axillary bud/apical meristem in Sodium alginate
(Total weight 1.5: Procedure – 0.5; Working/Preparation - 1)
4. Select the anther in appropriate stage for anther culture. Write down the selection criteria for the flower bud.
(Total weight 1.5: selection criteria – 0.5; Preparation – 1)
5. Comment on A, B, C, D, and E.
(Weight 1; 1 x 5 = 5)
6. Practical record
(Weight 2)

Key to the questions:
1. Preparation of plates and isolation of microbe has to be done 2-3 days before exam.
2. Give appropriate seeds
3. Give necessary reagents and materials
4. Give appropriate inflorescence
5. A, B, C, D, E - Chemicals, Instruments, Photographs/Diagrams related to tissue culture/microbial biotechnology procedures specified in the syllabus
6. Awarding 'A grade' to the record of practical work shall be considered only if all the practicals specified in the syllabus are completely done and recorded properly. This also includes field study report(s)/Lab visit report(s)/Industry visit report(s), if any.

ELECTIVE – BIOTECHNOLOGY

SEMESTER IV - PRACTICAL COURSE II

PBT4CRP0222: GENETIC ENGINEERING, GENOME EDITING, IMMUNOLOGY, GENOMICS, TRANSCRIPTOMICS, PROTEOMICS AND BIOINFORMATICS

Time: 4 hours **Weightage: 15**

1. Find out the phylogenetic relationship of *Homo sapiens neanderthalensis* Cytochrome C protein sequence with other 5 organisms.
(Total weight 3: Processing of the source file containing FASTA format – 1; MSA output – 1; Tree Creation - 1)
2. Blast search with the given nucleotide sequence (e.g. *Magnolia latahensis* sequence). Using the same sequences, carry out multiple sequence alignment.
(Total weight 3: Identification and FASTA sequence of phylogenetically related organisms – 1; BLAST SEARCH – 1; MSA output – 1)
3. Isolate DNA from the given plant material.
(Total weight 2: protocol – 1; Isolation – 1)
4. Separate Nucleic acid by agarose gel electrophoresis
(Total weight 2: Running efficiency – 1; Band vision – 1)
5. Comment on A, B, C and D
(Weight 0.5 x 4 = 2)
6. Work out the given problem E.
(Weight 1)
7. Practical record
(Weight 2)

Key to the questions:

1. Draw a phylogenetic tree using the gene sequence data file with the help of CLUSTAL X/W or MUSCLE and tree drawing tool
Centre can provide raw gene sequences of phylogenetically related organisms as a Text file.
2. Download protein sequences like *Magnolia latahensis* rbcL gene from genbank and save it in each desktop. Then use Clustal X/MUSCLE
3. Supply necessary tissue samples
4. Supply pure samples of DNA/RNA, and necessary buffer
5. A, B, C, D - Vectors, procedures or equipments (photographs) used in genetic engineering
6. E- Problems based on restriction digestion of DNA, gel separation pattern, genome mapping etc.
7. Awarding 'A grade' to the record of practical work shall be considered only if all the practicals specified in the syllabus are done completely recorded properly. This also includes field study report(s)/Lab visit report(s)/Industry visit report(s), if any.

GIST OF CHANGES

Semester	Course	Section	Deletion	Addition
1	MICROBIOLOGY AND PHYCOLOGY	Microbiology	MICROBIOLOGY Module 2 Archaebacteria. Extremophiles - thermophilic, halophilic, acidophilic and alkalophilic bacteria. Nutritional types, Bacterial genome chromosome, plasmids-types of plasmids-R plasmids, Col plasmids and F plasmids Module 5 Endophytic fungi Module 6 Structure of bacteriophages belonging to 'T' series- ultra structure of TMV. Practicals Inoculation of bacteria-stabbing and streaking Differential staining of bacteria using Gram stain. Endospore staining Isolation of Rhizobium from root nodules	MICROBIOLOGY Module 2 Antibiotics and their mode of action, bacterial resistance mechanisms, horizontal gene transfer, integrons. Module 6 Viral pathogens of humans and their management strategies with special reference to Nipah, SARS and Dengue. Practicals Biochemical tests – Indole, Methyl Red, Voges Proskauer, Citrate (IMViC), Urease and TSI
		Phycology	Practicals: Ecballocystopsis and Desmidium.	Practicals added: 1.Isolation and culturing of microalgae OR Estimation of photosynthetic pigments in microalgae. 2.One more component was added to the field visit part as another option:

				Students are to collect and identify algae from different habitat. Prepare and submit a report of the field work with sufficient photographs of algal collection. OR To visit an algal research centre and submit a report.
1	MYCOLOGY AND CROP PATHOLOGY	Mycology	Practicals- Physarum, Saprolegnia, Albugo, Saccharomyces, Xylaria,	Module-1 (To be added): Major criteria followed for fungal classification. Practicals 36 hours (To be added) 1.Spore isolation and root staining, On farm mycorrhizal inoculum production techniques using nurse crops of typical genus isolated and its maintenance. 2.Students should undergo training in mushroom cultivation (Pleurotus/ Calocybe) cultivation using locally available growing medium and then grow mushrooms in their own house, prepare a report and submit it with photographs along with their practical exam for valuation.
1	BRYOLOGY AND PTERIDOLOGY		No Change	
1	GYMNOSPERMS, EVOLUTION AND PALEOBOTANY		No Change	
2	PLANT ANATOMY, DEVELOPMENTAL BIOLOGY AND HORTICULTURE	Plant anatomy	Module 2: Meristem Apical organization: Stages of development of primary meristem and theories of apical organization (shoot and root). Practicals Study of stomatal types (Anomocytic,	Module 2: Meristem Shoot Development, Apical Meristem and types of vegetative shoot apex in Angiosperms, Cytological zonation, Sub-apical differentiation of tissues, Root Development, Organization of root apex. Practicals Double staining procedure for transverse sections of dicot stem and dicot leaf.

			anisocytic, paracytic and diacytic) and determination of stomatal index	
		Developmental Biology	No Change	
		Horticulture		Practicals: A hands-on-training in a well-established nursery to be attended by the students in order to procure necessary skill and expertise in the budding, grafting and layering procedure. The field report (in record) along with a budded/grafted/layered potted plant must be submitted for evaluation.
2	CELL BIOLOGY, GENETICS AND PLANT BREEDING		No Change	
2	PLANT PHYSIOLOGY AND BIOCHEMISTRY		No Change	
2	MOLECULAR BIOLOGY		No Change	
3	RESEARCH METHODOLOGY, MICROTECHNIQUE, BIOSTATISTICS AND BIOPHYSICAL INSTRUMENTATION		MICROTECHNIQUE Section of the paper removed.	The entire paper renamed as RESEARCH METHODOLOGY, PHYTOCHEMISTRY, BIOSTATISTICS AND BIOLOGICAL TECHNIQUES Introduced a new section PHYTOCHEMISTRY Theory (18 hrs) Module 1 (3 hours) Phytochemistry: Classification, history and scope of Phytochemistry. Recent advances in the field of chemical taxonomy. Phytochemical approach to economic botany. Plants in Medicine: Indigenous traditional drugs, traditional system of medicine, herbal medicine, folk medicine, unani and siddha medicine, ayurveda medicine and ethnopharmacology.

				Module 2 (8 hours) Plant Secondary Metabolites: Classification, structure and function of medicinally important plant products : glycosides, tannins, resins, oleoresins, volatile oils, alkaloids, carbohydrates, vitamins, proteins, fats, oils and waxes, phenolic compounds, plant acids, saponins, terpenoids, steroids, flavanols and flavones, betalins, pigments, dyes, gums and mucilage. Module 3 (7 hours) Essential Oils and Perfumery chemicals: occurrence, function, classification, structure, extraction and isolation techniques and essential oil analysis. Steam distillation, hydro distillation, solvent extraction, super critical fluid extraction. Application of essential oils – insecticides and perfumery products, uses and storage of essential oils and perfumery chemicals.Histochemical localization of starch, lipid and lignin. Flavouring agents. Aromatherapy. **PRACTICALS**: 27 hours Histochemical analysis of plant components. Estimation of water content, dry matter, ash content, total free amino acids, total proteins, total carbohydrates, free fatty acids, vitamins, pigments, tannins and alkaloids. Determination of acid value, iodine value and saponification value of oils. The students will have to attend an internship in Phytochemical techniques accompanied by a faculty member at a reputed organisation/institute for hands-on training.
3		Biophysical instrumentation	Module 1: Introduction to Microscopy renamed as Microscopy (No. of hours	Paper section title renamed as BIOLOGICAL TECHNIQUES

			reduced to 2) Parts of microscope Types of Microscopes- Simple and Compound Module 2: No. of hours reduced to 5 pH meter, Colorimeter Module 3 Basic Principles and Applications of Chromatography renamed as Separation and analytical techniques hours reduced to 3 Paper and thin layer chromatography **Practical: (18 Hrs)** 1.Micrometry; calibrate the ocular and stage micrometer on a light microscope and measure an object. 2.TLC 3.Calibrate the pH meter and measure the pH of different samples.	TO BE ADDED One new module added Module 5 Serial sectioning (3hrs) Serial Sectioning: Microtome, Paraffin embedding, serial sectioning and mounting **Practicals** 1.Seperation of molecules using HPLC (Demonstration only) 2.Separation of Plant pigments using column chromatography 3.Preparation of paraffin blocks and serial sections
3	BIOTECHNOLOGY, BIOINFORMATICS AND BIONANOTECHNOLGY	Bionanotechnolgy		References to be added ●Anil Kumar Anal (2020). Bionanotechnology Principles and applications. CRC Press Taylor & Francis Group. ●Christof M Niemeyer & Chad a Mirkin (2004). Nanobiotechnology: Concepts, applications and perspectives. Wiley. ●Amretashis Sengupta & Chandan Kumar Sarkar (2015). Introduction to Nano Basics to Nanoscience and

				Nanotechnology. Springer. ●Ravindra Pratap Singh & Kshitij R B Singh (2021). Nanomaterials in Bionanotechnology Fundamentals and applications. CRC Press Taylor & Francis Group. ●Ram Prasad, Vivek Kumar, Manoj Kumar & Devendra choudhary (2019). Nano-biotechnology in Bioformulations. Springer.
3	ANGIOSPERM TAXONOMY, ECONOMIC BOTANY AND ETHNOBOTANY		No change	
3	ENVIRONMENTAL SCIENCE		No change	
4	Elective papers:	Plant Tissue Culture and Microbial Biotechnology	No change	
		Genetic Engineering, Genome Editing, Immunology	No change	
		Genomics, Transcriptomics, Proteomics and Bioinformatics	No change	