MAR ATHANASIUS COLLEGE (AUTONOMOUS)

KOTHAMANGALAM, KERALA 686 666

NAAC Accredited 'A^{+}' Grade Institution

Email: mac@macollege.in

www.macollege.ac.in

SCHEME AND SYLLABUS

FOR

POSTGRADUATE PROGRAMME

UNDER CREDIT SEMESTER SYSTEM

MAC-PG-CSS 2025

IN

M.Sc. BOTANY

EFFECTIVE FROM THE ACADEMIC YEAR 2025-2026

BOARD OF STUDIES IN BOTANY (PG)

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ACADEMIC COUNCIL COMPOSITION

Effective from 2022-2023

Chairperson	Dr. Manju Kurian	Principal Mar Athanasius College (Autonomous), Kothamangalam
Experts/Academicians from outside the college representing such areas as Industry, Commerce, Law, Education, Medicine, Engineering, Sciences etc.	Dr. Winny Varghese	Secretary Mar Athanasius College Association Kothamangalam
	Dr. R K Chauhan	Former Vice Chancellor, Lingaya's University Faridabad, Haryana -121002
	Prof. Dr. V N Rajasekharan Pillai	Former Vice Chairman University Grants Commission New Delhi
	Dr. Sheela Ramachandran	Pro Chancellor Atmiya University Rajkot
	Dr. M C Dileep Kumar	Former Vice Chancellor Sree Sankaracharya Sanskrit University Kalady, Kerala, India
	Dr. Bos Mathew Jos	Principal Mar Athanasius College of Engineering Kothamangalam, Kerala - 686 66
	Adv. George Jacob	Senior Advocate High Court of Kerala Ernakulam

Nominees of the University	Dr. Raju Francis	Professor, School of Chemical Sciences, Mahatma Gandhi University
	Dr. G. Anilkumar	Professor, School of Chemical Sciences, Mahatma Gandhi University
	Dr. J.G. Ray	Professor. School of Biosciences Mahatma Gandhi University
Member Secretary	Dr. Latha S Nair	Associate Professor in Mathematics, Mar Athanasius College (Autonomous) Kothamangalam
Four teachers of the college representing different categories of teaching staff.	Dr. Aby P. Varghese	Vice Principal
	Dr. Aji Abraham	Controller of Examinations
	Dr. Rajesh K.Thumbakara	Dean of Research
	Dr. Binu Varghese	Dean Academics
Heads of the Departments	Ms. Shiny John, Head, Department of Computer Science Dr. Smitha Thankachan, Head, Department of Physics Dr. Annu Anna Varghese, Head, Department of Chemistry Dr. Eldhose A. M, Head, Department of Economics Dr. Selven S, Head, Department of Zoology Dr. Asha Mathai, Head, Department of Malayalam Dr. Latha S. Nair, Head, Department of Mathematics Dr. Alphonsa C. A, Head, Department of English Dr. Diana Ann Issac, Head, Department of Commerce Dr. Sibi M. M, Head, Department of Hindi	

	Dr. Siju Thomas T, Head, Department of Botany Dr. Diana Mathews, Head, Department of Sociology Ms. Sudha V, Head, Department of Statistics Dr. Jani Chungath, Head, Department of History Mr. Haary Benny Chettiamkudiyil , Head, Department of Physical Education Ms. Minnu Jose, Head, Integrated Biology Ms. Shari Sadasivan, Head, Department of Marketing and International Business Ms. Simi Varghese, Head, Department of Commerce (B Com Tax) Mr. Paul George, Head, Department of Biotechnology Dr. Nivya Mariyam Paul, Head, Department of Microbiology Ms. Elizabeth Jacob, Head, Department of Biochemistry Ms. Shalini Binu, Head, Department of Actuarial Science Ms. Sari Thomas, Head, Post Graduate Department of Statistics Ms. Sharon V Balakrishnan, Head, Post Graduate Department of Sociology Ms. Deepasree P. M, Head, Post Graduate Department of Zoology Ms. Joslin Jose, Head, B.Voc in Business Accounting and Taxation Ms. Christeena Merin Babu, Head, B.Voc in Data Analytics and Machine Learning Ms. Merin C Kuriakose, Head, Post Graduate Department of Data Analytics

MAR ATHANASIUS COLLEGE (AUTONOMOUS), KOTHAMANGALAM

Members of the Board of Studies - PG Programme

Subject: BOTANY

Chairperson	**Dr. Siju Thomas T** Assistant Professor and Head Department of Botany, Mar Athanasius College (Autonomous), Kothamangalam.
Experts (2) (Outside University)	**1. Dr. Dennis Thomas T** Professor, Department of Plant Science, Central University of Kerala, Kasargod.
	2. Dr. Santhosh Nampy Professor, Department of Botany, University of Calicut, Thenhipalam, Malappuram.
One Expert - nominated by VC (M. G. University)	**Dr. E. A. Siril** Professor and Head, Department of Botany, University of Kerala, Kariavattom, Thiruvananthapuram
Member from Industry	**Dr. Safeer P. M** Director, CIRIST Ecosystem Pvt. Ltd., Kinfra Hitech Park, Kalamassery, Ernakulam.
Meritorious Alumnus	**Dr. Giby Kuriakose** Assistant Professor, Department of Botany, Sacred Heart College (Autonomous), Thevara, Kochi.
Other Members of the Department	**1. Dr. Aji Abraham** Associate Professor, Mar Athanasius College (Autonomous), Kothamangalam.
	2. Ms. Meril Sara Kurian Assistant Professor, Mar Athanasius College (Autonomous), Kothamangalam.
	3. Dr. Sarath G Nair Assistant Professor, Mar Athanasius College (Autonomous), Kothamangalam.

	4. Dr. Jayalakshmi P. S. Assistant Professor, Mar Athanasius College (Autonomous), Kothamangalam
	5. Dr. Akhila Sen Assistant Professor, Mar Athanasius College (Autonomous), Kothamangalam
	6. Ms. Anu Mariya Mathai Assistant Professor on contract, Mar Athanasius College (Autonomous), Kothamangalam.
Special Invitees if any	

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PREFACE

It is with great pleasure we introduce the newly revised syllabus for the M.Sc. Botany programme, designed with an outcome-based approach to provide a comprehensive understanding of the subject. This revised curriculum incorporates the latest developments in Botany and allied disciplines, ensuring that students are equipped with modern knowledge and practical skills to meet academic and professional challenges.

The new syllabus integrates advancements in plant sciences, biotechnology, molecular biology, environmental biology, and bioinformatics, among other emerging fields. Aligning with the principles of National Educational Policy (2020), special emphasis has been placed on fostering critical thinking, research aptitude, and entrepreneurial skills among students. The main objective is to prepare students not only for academic excellence but also for exploring successful careers in plant sciences, innovative research and entrepreneurship.

We extend our sincere gratitude to the Management, University and the Principal for their unwavering support and guidance in this endeavour. We also appreciate the valuable contributions of faculty members, subject experts, and all stakeholders who have contributed to revising this curriculum to meet the evolving needs of higher education and society.

We hope that this revised syllabus will provide a strong foundation for the students, motivating them to excel in their academic pursuits and contribute to the sustainable development of the society.

Chairperson and Members
Board of Studies in Botany

REGULATIONS OF THE POSTGRADUATE PROGRAMMES UNDER CREDIT SEMESTER SYSTEM MAC-PG-CSS 2025 (2025 Admission onwards)

1. SHORT TITLE

1.1 These Regulations shall be called "Mar Athanasius College (Autonomous) Regulations (2025) governing Postgraduate Programmes under the Credit Semester System (MAC-PG-CSS 2025)".

1.2 These Regulations shall come into force from the Academic Year 2025-2026.

2. SCOPE

2.1 The regulations provided herein shall apply to all Regular Postgraduate (PG) Programmes, M.A. /M.Sc. /M.Com. conducted by Mar Athanasius College (Autonomous) with effect from the academic year 2025-2026 admission onwards.

3. DEFINITIONS

3.1 **'Academic Committee'** means the Committee constituted by the Principal under this regulation to monitor the running of the Post-Graduate programmes under the Credit Semester System (MAC-PG-CSS 2025).

3.2 **'Academic Week'** is a unit of five working days in which the 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 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 **'College Co-ordinator'** means a teacher from the college nominated by the Principal to look into the matters relating to MAC-PG-CSS 2025 for programmes conducted in the College.

3.6 **'Comprehensive Viva-Voce'** means the oral examinations conducted by the appointed examiners and shall cover all courses of study undergone by a student for the programme.

3.7 **'Common Course'** is a core course which is included in more than one program with the same course code.

3.8 '**Core Course**' means a course that the student admitted to a particular programme must successfully complete to receive the Degree and which cannot be substituted by any other course.

3.9 '**Course**' means a 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/evaluation etc., to meet effective teaching and learning needs.

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

3.11 'Course Credit' One credit of the course is defined as a minimum of one-hour lecture /minimum of 2 hours of lab/field work per week for 18 weeks in a Semester. The course will be considered as completed only by conducting the final examination.

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

3.13 '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.

3.14 '**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**.

3.15 '**Cumulative Grade Point Average (CGPA)**' is the value obtained by dividing the sum of credit points in all the courses taken by the student for the entire 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 a programme.

(CGPA = Total CP obtained/ Total credits of the programme)

3.16 '**Department**' means any teaching Department offering a programme of study in the institution.

3.17 '**Department Council**' means the body of all teachers of a Department in a College.

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

3.19 '**Duration of 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.

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

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

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

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

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

3.25 '**Faculty Advisor'** is a teacher nominated by a Department Council to coordinate the continuous evaluation and other academic activities undertaken in the Department.

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

3.27 '**Grade Point'** (GP) Each letter grade is assigned a Grade point (GP) which is an integer indicating the numerical equivalent of the broad level of performance of a student in a course.

3.28 '**Grade Point Average (GPA)**' is an index of the performance of a 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)**

3.29 '**Improvement Course**' is a course registered by a student to improve his performance in that particular course.

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

3.31 '**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.

3.32 MAC-PG-CSS 2025 means Mar Athanasius College Regulations Governing Post Graduate programmes under Credit Semester System, 2025.

3.33 '**Parent Department'** means the Department which offers a particular postgraduate programme.

3.34 '**Plagiarism**' is the unreferenced use of other authors‟ material in dissertations and is a serious academic offence.

3.35 '**Programme**' means the entire course of study and Examinations.

3.36 'Project' is a core course in a programme. It means regular project work with stated credits on which the student undertakes a project under the supervision of a teacher in the parent department/ any appropriate research centre to submit a dissertation on the project work as specified. It allows students to work more autonomously to construct their learning and culminates in realistic, student-generated products or findings.

3.37 '**Repeat Course**' is a course to complete the programme in an earlier registration.

3.38 '**Semester**‟ means a term consisting of a minimum of 90 working days, inclusive of examination, distributed over a minimum of 18 weeks of 5 working days each.

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

3.40 '**Semester Grade Point Average (SGPA)**' is the value obtained by dividing the sum of credit points (CP) obtained by the 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 a semester (SGPA = Total CP obtained in the semester / Total Credits for the semester).

3.41 '**Tutorial**' means a class to provide an opportunity to interact with students at their individual level to identify the strengths and weaknesses of individual students.

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

3.43 University means Mahatma Gandhi University Kottayam to which the college is affiliated.

3.44 '**Weighted Grade Point (WGP)**‟ is grade points multiplied by weight. **(WGP=GPxW)**

3.45 '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.

4. ACADEMIC COMMITTEE

4.1. There shall be an Academic Committee constituted by the Principal to Manage and monitor the working of MAC-PG-CSS 2025.

4.2. The Committee consists of:

1. Principal
2. Dean, Administration
3. Dean, Academics
4. IQAC Coordinator
5. Controller of Examinations
6. One Faculty each representing Arts, Science, Commerce, Languages, and Self Financing Programmes

5. PROGRAMME STRUCTURE

5.1 Students shall be admitted to postgraduate programmes under the various Faculties. The programme shall include three types of courses, Core Courses, Elective Courses and Common core courses. There shall be a project with a dissertation and comprehensive viva voce as core courses for all programmes. The programme shall also include assignments/seminars/practicals etc.

5.2 No regular student shall register for more than 25 credits and less than 16 credits per semester unless otherwise specified. The total minimum credits, required for completing a PG programme is 80.

5.3. Elective Courses and Groups

5.3.1 There shall be various groups of Programme Elective courses for a Programme such as Group A, Group B etc. for the choice of students subject to the availability of facility and infrastructure in the institution and the selected group shall be the subject of specialization of the programme.

5.3.2 The elective courses shall be either in the fourth semester or distributed among the third and fourth semesters. There may be various groups of Elective courses (three elective courses in each group) for a programme such as Group A, Group B etc. for the choice of students, subject to the availability of facilities and infrastructure in the institution.

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

5.3.4 The elective groups selected for the various Programmes shall be intimated to the Controller of Examinations within two weeks of the commencement of the semester in which the elective courses are offered. The elective group selected for the students who are admitted in a particular academic year for various programmes shall not be changed.

5.4 P*roject Work*

5.4.1. Project work shall be completed following the guidelines given in the curriculum.

5.4.2 Project work shall be carried out under the supervision of a teacher of the department concerned.

5.4.3 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.

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

5.4.5 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.

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

5.4.7 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 shall submit at least one assignment as an internal component for each course.

5.6 Seminar Lecture: Every PG 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 in self-study, collection of relevant matter from the various resources, editing, document writing and presentation.

5.7 Test Papers (Internal): Every PG student shall undergo at least two class Tests as an internal component for every course with a weight of one each. The best two shall be taken for awarding the grade for class tests.

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

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

5.9.1. Comprehensive Viva-Voce shall 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 appearing at the end-semester examination shall be 75% for male students and 73% for female students. Condonation of shortage of attendance to a maximum of 15 days in a semester subject to a maximum of two times during the whole period of the programme may be granted by the University.

6.2 If a student represents his/her institution, University, State or Nation in Sports, NCC, 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 15 days in a Semester based on the specific recommendations of the Head of the Department or teacher concerned.

6.3 Those who could not register for the examination of a particular semester due to a shortage of attendance may repeat the semester along with junior batches, without considering sanctioned strength, subject to the existing University Rules and Clause 7.2.

6.4. A Regular student who has undergone a programme of study under an earlier regulation/ Scheme and could not complete the Programme due to a shortage of attendance may repeat the semester along with the regular batch subject to the condition that he has to undergo all the examinations of the previous semesters as per the MAC-PG-CSS 2025 regulations and conditions specified in 6.3.

6.5 A student who had sufficient attendance and could not register for the fourth- semester examination can appear for the end-semester examination in the subsequent years with the attendance and progress report from the principal

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 registered for the Programme shall complete the Programme within a period of four years from the date of commencement of the programme.

7.3 Students are eligible to pursue studies for additional postgraduate degrees. They shall be eligible for the award of a degree only after successful completion of two years (four semesters of study) of college-going.

8. ADMISSION

8.1 The admission to all PG programmes shall be done through the Centralised Allotment Process of Mar Athanasius College (Autonomous), Kothamangalam (MAC-PG CAP) as per the rules and regulations prescribed by the affiliating University and the Government of Kerala from time to time.

8.2 The eligibility criteria for admission shall be announced by the Parent University from time to time.

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 Mahatma Gandhi University as specified or any other examination of any recognized University or authority accepted by the Academic Council of Mahatma Gandhi University as eligible thereto.

9.2 Students admitted under this programme are governed by the Regulations in force.

10. PROMOTION:

10.1 A student who registers for the end-semester examination shall be promoted to the next semester.

10.2 A student who has 75% attendance (73% for girl students) and who fails to register for the examination of a particular semester will be allowed to register notionally and is promoted to the next semester, provided the application for notional registration shall be submitted within 15 days from the commencement of the next semester.

10.3 The medium of Instruction shall be English except for programmes under the faculty of Language and Literature.

11. EXAMINATIONS

11.1 End-Semester Examinations: The examinations shall be at the end of each Semester of three-hour duration for each centralised and practical course.

11.2 Practical examinations shall be conducted at the end of each semester or at the end of even semesters as prescribed in the syllabus of the particular programme. The number of examiners for the practical examinations shall be prescribed by the Board of Studies of the programmes.

11.3 A question paper may contain short answer type/annotation, short essay type questions/problems 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). 25% weightage shall be given to internal evaluation and the remaining 75% to external evaluation and the ratio and weightage between internal and external is 1:3. Both End Semester Evaluation (ESE) and Continuous Evaluation (CE) shall be carried out using a 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 grades shall be assigned to each course based on the categorisation provided in 12.16.

12.4 Internal evaluation: The internal evaluation shall be based on a predetermined transparent system of 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 are based on the Direct Grading System.

Proper guidelines shall be prepared by the BOS for evaluating the assignment, seminar, practical, project and 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 their weightage for Continuous Evaluation (CE) and End Semester Evaluation (ESE) are shown below:

a) For Theory (CE) (Internal)

	Components	**Weightage**
i.	Assignment	1
ii.	Seminar	2
iii.	Best Two Test Papers	2(1 each)
Total		**5**

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

b) For Theory (ESE) (External)

Evaluation is based on the pattern of Questions specified in **12.15.5**

c) For Practical (CE) (Internal)

Components	**Weightage**
Written / Lab Test	2
Lab Involvement and Record	1
Viva	2
Total	**5**

(The components and weightage 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	7

Lab Involvement and Record	3
Viva	5
Total	**15**

(The components and 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 (ESE) (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.)

12.8 All grade point averages shall be rounded to two digits.

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 external examination.

12.10 There shall not be any chance for improvement in the Internal Grade.

12.11 The course teacher and the faculty advisor shall maintain the academic record of each student registered for the course and a copy should be kept in the college for verification for at least two 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 may be written in English or Malayalam except 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 University.

12.14 The question paper should be strictly based on the model question paper set and directions prescribed by the BOS.

12.15. **Pattern of Questions**

12.15.1. **Questions shall be set to assess knowledge acquired, standard, and application of knowledge, application of knowledge in new situations, critical evaluation of knowledge and the ability to synthesize knowledge. Due weightage 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 skills are set.

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 question shall be prepared in such a way that the answers can be awarded A+, A, B, C, D, and 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 the question 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 point(G)	Grade Range
A+	5	4.50 to 5.00
A	4	4.00 to 4.49
B	3	3.00 to 3.99
C	2	2.00 to 2.99
D	1	0.01 to 1.99
E	0	0.00

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.

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**
up to 1.99	**D**	**Deficient(Fail)**

12.19 **No separate minimum is required for Internal Evaluation for a pass, but a minimum grade is required for a pass in an External Evaluation.**

However, a minimum C grade is required to pass 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 candidate who wishes to improve the grade/grade point of the external examination of the 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 the first and second semesters of the programme.

12.22 **One-Time Betterment Programme**- A candidate will be permitted to improve the **CGPA** of the programme within a continuous period of four semesters immediately following the completion of the programme allowing only once for a particular semester. The **CGPA** for the betterment appearance will be computed based on the **SGPA** secured in the original or betterment appearance of each semester whichever is higher.

If a candidate opts for the betterment of **CGPA** of a programme, he/she has to appear for the external examination of the entire semester(s) excluding practical /project/comprehensive viva voce. One time betterment programme is restricted to students who have passed all courses of the programme at the regular (First appearance)

12.23 **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 a semester to the total credit for that semester. After the successful completion of a semester, the 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 a semester / 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 the i^{th} course.

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

Cumulative Grade Point Average (CGPA) = $\sum(C_i \times S_i) / \sum C_i$
(CGPA= Total credit Points awarded in all semesters / Total credits of the programme)

Where "C_i" is the credit for the i^{th} semester, "S_i" is the SGPA for the i^{th} semester. The **SGPA** and **CGPA** shall be rounded off to 2 decimal points.

For the successful completion of the 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 Institution 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 the University.
b) Name of college
c) Title of the PG Programme.
d) Name of Semesters
e) Name and Register Number of students
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 programme.
k) Separate Grade cards will be issued.
l) Details of the description of the 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 a '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 constituted by the Principal to monitor the internal evaluations conducted.

16. RANK CERTIFICATE

Rank certificates shall be issued to candidates who secure positions 1^{st} and 2^{nd}. 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 the rank. Rank certificate shall be signed by the Principal and the Controller of Examinations.

17. GRIEVANCE REDRESSAL COMMITTEE

17.1 Department level: The College shall form a Grievance Redressal Committee in each Department comprising 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 grades of the students.

17.2. College level: There shall be a college-level Grievance Redressal Committee comprising the faculty advisor, college co-ordinator, one senior teacher, one staff council member and the Principal as Chairperson.

18. FACTORY VISIT / FIELD WORK/VISIT: Factory visit/fieldwork/visit to a reputed research institute/ student interaction with renowned academicians may be conducted for all Programmes before the commencement of Semester III.

19. INTERNSHIP/ON-THE-JOB TRAINING: Each student shall undertake internship/on-the-job training for a period of not less than 15 days. The time, duration and structure of internship/on-the-job training can be modified by the concerned Board of Studies.

20. TRANSITORY PROVISION

Notwithstanding anything contained in these regulations, the Principal shall, for a period of three 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.

21. REPEAL

The Regulations now in force in so far as they are applicable to programmes offered by the college and to the extent they are inconsistent with these regulations are hereby repealed. In the case of any inconsistency between the existing regulations and these regulations relating to the Credit Semester System in their application to any course offered in a College, the latter shall prevail.

22. Credits allotted for Programmes and Courses

22.1 Total credit for each programme shall be **80**.

22.2 Semester-wise total credit can vary from 16 to 25

22.3 The minimum credit of a course is 2 and the maximum credit is 5

23. Common Course: If a course is included as a common course in more than one programme, its credit shall be the same for all programmes.

24. Course Codes: The course codes assigned for all courses (Core Courses, Elective Courses, Common Courses etc.) shall be unique.

25. The distribution of courses, course codes, type of course, credits, and teaching hours for the M. Sc. Botany programme are given in the following table.

Programme with practical -Total Credits 80
M. Sc. Botany Programme
SCHEME AND PROGRAMME STRUCTURE

Course Code	Course Title	Teaching Hours		Credits
		Theory	Practical	
Semester I				
PG25BO101	Microbiology and Phycology	27 + 45	9 + 36	4
PG25BO102	Mycology and Crop Pathology	36 + 36	36 + 18	4
PG25BO103	Bryophytes, Pteridophytes and Gymnosperms	18 +36 +18	9+18+18	4
PG25BO104	Research Methodology, Biostatistics and Biophysical instrumentation	18+18+18	9+9+18	3
PG25BOP1	Practical of Microbiology and Phycology & Mycology and Crop Pathology			2
PG25BOP2	Practical of Bryophytes, Pteridophytes and Gymnosperms & Research Methodology, Biostatistics and Biophysical instrumentation			2
	Total for Semester I	***270***	***180***	***19***
Semester II				
PG25BO205	Plant Anatomy and Microtechnique	36+36	27+27	4
PG25BO206	Cell Biology, Developmental Biology and Immunology	45+18+9	27+18	4
PG25BO207	Biotechnology, Bioinformatics and Bionanotechnology	54+18	27+9	4
PG25BO208	Ecology and Environmental Science	54	18	3
PG25BOP3	Practical of Plant Anatomy and Microtechnique & Cell Biology, Developmental Biology and Immunology			2
PG25BOP4	Practical of Biotechnology, Bioinformatics and Bionanotechnology & Ecology and Environmental Science			2
	Total for Semester II	***270***	***180***	***19***
Semester III				
PG25BO309	Plant Physiology and Biochemistry	45+27	36+27	4
PG25BO310	Genetics, Plant Breeding and Horticulture	36+18+18	36+9+9	4
PG25BO311	Angiosperm taxonomy, Economic Botany and Ethnobotany	63+9	63	4
PG25BO312	Molecular Biology	54	27	3
PG25BOP5	Practical of Plant Physiology and Biochemistry & Genetics, Plant Breeding and Horticulture			2

PG25BOP6	Practical of Angiosperm taxonomy, Economic botany and Ethnobotany & Molecular Biology			2
	Total for Semester III	***270***	***180***	***19***
Semester IV – Elective course				
Elective Group I – Biotechnology (Offered by the Department)				
PG25BO413	Elective - Plant tissue culture and Microbial Biotechnology	90	72	4
PG25BO414	Elective - Genetic Engineering	90	54	4
PG25BO415	Elective - Genomics, Transcriptomics, Proteomics and Bioinformatics	90	54	4
PG25BOP7	Practical of Plant tissue culture and Microbial Biotechnology			2
PG25BOP8	Practical of Genetic Engineering & Genomics, Transcriptomics, Proteomics and Bioinformatics			2
	Elective Group II - Microbiology			
PG25BO416	Food, Agriculture and Environmental Microbiology	90	72	4
PG25BO417	Clinical Microbiology	90	54	4
PG25BO418	Industrial Microbiology	90	54	4
PG25BOP9	Practical of Food, Agriculture and Environmental Microbiology			
PG25BOP10	Practical of Clinical Microbiology & Industrial Microbiology			
	Elective Group III – Environmental Science			
PG25BO419	Basic concepts in Environmental Studies	90	72	4
PG25BO420	Natural resources and their management	90	54	4
PG25BO421	Environmental monitoring and management	90	54	4
PG25BOP11	Practical of Basic concepts in Environmental Studies			
PG25BOP12	Practical of Natural resources and their management & Environmental monitoring and management			
PG25BO4P	Project			4
PG25BO4V	Comprehensive viva voce			3
	Total for Semester IV			***23***
	Total for the Programme	***270***	***180***	***80***

Appendix

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

Grade	Grade Points	Range
A+	**5**	**4.50 to 5.00**
A	**4**	**4.00 to 4.49**
B	**3**	**3.00 to 3.99**
C	**2**	**2.00 to 2.99**
D	**1**	**0.01 to 1.99**
E	**0**	**0.00**

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**
Upto1.99	**D**	**Deficient(Fail)**

Theory-External-ESE

The 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	19	A+	5	5	25
	20	-	-	-	-
	21	-	-	-	-
	22	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

The 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**
Assignment	1	A	4	4	**WGP/Total Weight= 24/5 =4.8**
Seminar	2	A+	5	10	
Test Paper 1	1	A+	5	5	
Test Paper 2	1	A+	5	5	
Total	**5**			**24**	**A+**

Practical-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**
Written/Lab Test	7	A	4	28	**WGP/Total Weight= 58 / 15 = 3.86**
Lab involvement & record	3	A+	5	15	
Viva	5	B	3	15	
Total	**15**			**58**	**B**

Practical-Internal-CE

The 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

The 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	3	C	2	6	**WGP/Total Weight = 56/15= 3.73**
Project Content & Presentation	7	A+	5	35	
Project Viva- Voce	5	B	3	15	
Total	**15**			**56**	**B**

Project-Internal-CE

The 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

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

Components	**Weight (W)**	**Grade Awarde**	**Grade Point(GP)**	**WGP=W*G P**	**Overall Grade of the Course**

		d			
Comprehensive viva-voce	15	A	4	60	**WGP/Total Weight = 60 / 15 = 4**
Total	**15**			**60**	**A**

Comprehensive viva-voce-Internal-CE

The 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+**

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

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

The End Semester Evaluation (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**			

2. **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**				

3. Evaluation Third 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), semester 4(SGPA of semester 4) and **B** grades in semester 3(SGPA of semester 3). Then 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 between 4.00 and 4.49 in a 7-point scale)** **Therefore the overall Grade awarded in the programme is A**				

ELIGIBILITY FOR ADMISSION TO M. Sc. BOTANY PROGRAMME

Academic eligibility should be satisfied as of the last date of submission of academic data. No candidate shall be admitted to the PG programme unless he/she possesses the qualifications and minimum requirements thereof, as prescribed by Mahatma Gandhi University from time to time.

If an applicant for admission is found to have indulged in ragging in the past or if it is noticed later that he/she had indulged in ragging, admissions shall be denied or he/she will be expelled from Mar Athanasius College (Autonomous), Kothamangalam.

Candidates should have passed the corresponding Degree Examination under the 10 + 2 + 3 pattern with one core/main subject and two complementary/subsidiary subjects from any of the Universities in Kerala or of any other University recognized by Mahatma Gandhi University as equivalent thereto for admission, subject to the stipulation regarding marks.

OR

Candidates who have passed the Degree examination with Double or Triple main subject and candidates who have passed the Degree Examination in Vocational or Specialized Programmes are also eligible for admission. However, they have to submit a copy of the Equivalency/Eligibility Certificate from Mahatma Gandhi University, stating that, their Qualifying Examination is recognized for seeking admission to the relevant P.G. Degree Programme(s) as applicable, at the time of admission. This provision is not applicable in the case of those applicants who have passed their qualifying examination from MG University.

The minimum requirements for admission to M. Sc. Programme in Botany is:

Graduates who have passed qualifying examination in CBCS (2017)/CBCSS (2013) pattern	**Graduates who have passed the qualifying examination in CBCSS (2009) pattern**	**Graduates who have passed qualifying examinations in other patterns**
Graduation in Botany or Botany - Biotechnology (double main) with not less than CGPA/CCPA of 5.00 out of 10.00 in the Core group (Core + Open + Complementary).	Graduation in Botany or Botany - Biotechnology (double main) with not less than CGPA of 2.00 out of 4 in the Core Group (Core + Open + Complementary).	Graduation in Botany or Botany-Biotechnology (double main) with not less than 50% marks in the Part III Subjects (Main/Core + subsidiaries/Complementaries).
No weightage marks.		

The Open course under the core group is taken only for reckoning the eligibility for applying for the PG programmes concerned. However, a candidate cannot apply for the respective PG programmes solely on the basis of the open course selected under the core group.

Relaxation in Marks in the qualifying examination:

(i) **Kerala Scheduled Caste/Scheduled Tribe Category**: The minimum grade in the qualifying examination for admission to the PG Degree programmes is „C" on the seven-point scale for CBCSS and a pass for pre-CBCSS applicants.

(ii) **SEBC Category**: A relaxation of 3% marks in the qualifying examination from the prescribed minimum is allowed i.e. CGPA of 4.7 for CBCS (2021)/CBCS (2017), CCPA of 4.7 for CBCSS (2013), and CGPA of 1.88 for CBCSS (2009) applicants and 47% marks for pre-CBCSS applicants.

(iii) **OEC Category:** A relaxation of 5% marks in the qualifying examination from the prescribed minimum is allowed i.e. CGPA of 4.5 for CBCS (2021)/CBCS (2017), CCPA of 4.5 for CBCSS (2013), CGPA of 1.80 for CBCSS (2009) applicants and 45% marks for pre - CBCSS applicants.

(iv) **Persons with Disability category**: A relaxation of 5% marks in the qualifying examination from the prescribed minimum is allowed i.e. CGPA of 4.5 for CBCS (2021)/CBCS (2017), CCPA of 4.5 for CBCSS (2013), CGPA of 1.80 for CBCSS (2009) applicants and 45% marks for pre – CBCSS applicants.

POSTGRADUATE PROGRAMME OUTCOME (PO):

At the end of the programme, the graduate will be able to

PO No.	Upon completion of the postgraduate program, the students will be able to:
PO1	Demonstrate in-depth knowledge and expertise in the chosen field of study
PO2	Inculcate creative capabilities, critical thinking, and problem-solving skills
PO3	Promote independent and collaborative research
PO4	Apply theoretical knowledge to real-world situations
PO5	Promote ethical standards and professional integrity in academics and research
PO6	Enhance communication, presentation, and leadership skills
PO7	Embrace interdisciplinary and innovative approaches to learning and research
PO8	Foster entrepreneurship skills and promote industry-academia linkage
PO9	Enhance sustainable development practices
PO10	Instill the spirit of justice, equality, and human rights for a fair and inclusive society

Programme Specific Outcomes (PSO) of M. Sc. Botany Programme

PSO No.	Upon completion of M.Sc. Botany Programme, the students will be able to:	PO No.
PSO-1	Interpret diversity, origin and evolution of plants on earth, identify different plant groups and conserve biodiversity.	1
PSO-2	Appraise plant metabolic processes, methodologies, techniques and recent advances in Botany and its allied branches.	1,2
PSO-3	Analyze and evaluate experimental data using biological and statistical tools and document the findings.	2,3
PSO-4	Explain concepts and develop skills with multidisciplinary dimensions and get motivated for knowledge creation and entrepreneurship	4,7,8
PSO-5	Acquire and apply knowledge for problem-solving, research, and lifelong learning while effectively summarizing and disseminating scientific ideas and research findings.	3,4,5,6
PSO-6	Create environmental consciousness among fellow citizens and work towards sustainable development of the nation and world at large.	9,10

M. Sc. Botany Programme

PROGRAMME STRUCTURE

Course Code	Course Title	Teaching Hours		Credits
		Theory	Practical	
Semester I				
PG25BO101	Microbiology and Phycology	27 + 45	9 + 36	4
PG25BO102	Mycology and Crop Pathology	36 + 36	36 + 18	4
PG25BO103	Bryophytes, Pteridophytes and Gymnosperms	18 +36 +18	9+18+18	4
PG25BO104	Research Methodology, Biostatistics and Biophysical instrumentation	18+18+18	9+9+18	3
PG25BOP1	Practical of Microbiology and Phycology & Mycology and Crop Pathology			2
PG25BOP2	Practical of Bryophytes, Pteridophytes and Gymnosperms & Research Methodology, Biostatistics and Biophysical instrumentation			2
	Total for Semester I	***270***	***180***	***19***
Semester II				
PG25BO205	Plant Anatomy and Microtechnique	36+36	27+27	4
PG25BO206	Cell Biology, Developmental Biology and Immunology	45+18+9	27+18	4
PG25BO207	Biotechnology, Bioinformatics and Bionanotechnology	54+18	27+9	4
PG25BO208	Ecology and Environmental Science	54	18	3
PG25BOP3	Practical of Plant Anatomy and Microtechnique & Cell Biology, Developmental Biology and Immunology			2
PG25BOP4	Practical of Biotechnology, Bioinformatics and Bionanotechnology & Ecology and Environmental Science			2
	Total for Semester II	***270***	***180***	***19***
Semester III				
PG25BO309	Plant Physiology and Biochemistry	45+27	36+27	4
PG25BO310	Genetics, Plant Breeding and Horticulture	36+18+18	36+9+9	4
PG25BO311	Angiosperm taxonomy, Economic Botany and Ethnobotany	63+9	63	4
PG25BO312	Molecular Biology	54	27	3
PG25BOP5	Practical of Plant Physiology and Biochemistry & Genetics, Plant Breeding and Horticulture			2

PG25BOP6	Practical of Angiosperm taxonomy, Economic botany and Ethnobotany & Molecular Biology			2
	Total for Semester III	***270***	***180***	***19***
Semester IV – Elective course				
Elective Group I – Biotechnology (Offered by the Department)				
PG25BO413	Elective - Plant tissue culture and Microbial Biotechnology	90	72	4
PG25BO414	Elective - Genetic Engineering	90	54	4
PG25BO415	Elective - Genomics, Transcriptomics, Proteomics and Bioinformatics	90	54	4
PG25BOP7	Practical of Plant tissue culture and Microbial Biotechnology			2
PG25BOP8	Practical of Genetic Engineering & Genomics, Transcriptomics, Proteomics and Bioinformatics			2
	Elective Group II - Microbiology			
PG25BO416	Food, Agriculture and Environmental Microbiology	90	72	4
PG25BO417	Clinical Microbiology	90	54	4
PG25BO418	Industrial Microbiology	90	54	4
PG25BOP9	Practical of Food, Agriculture and Environmental Microbiology			
PG25BOP10	Practical of Clinical Microbiology & Industrial Microbiology			
	Elective Group III – Environmental Science			
PG25BO419	Basic concepts in Environmental Studies	90	72	4
PG25BO420	Natural resources and their management	90	54	4
PG25BO421	Environmental monitoring and management	90	54	4
PG25BOP11	Practical of Basic concepts in Environmental Studies			
PG25BOP12	Practical of Natural resources and their management & Environmental monitoring and management			
PG25BO4P	Project			4
PG25BO4V	Comprehensive viva voce			3
	Total for Semester IV			***23***
	Total for the Programme	***270***	***180***	***80***

SEMESTER I

Course Code	Title	Teaching hrs theory	Teaching hrs practical	Credit
PG25BOI01	Microbiology and Phycology	27+45	9+36	4
PG25BOI02	Mycology and Crop pathology	36+36	36+18	4
PG25BOI03	Bryophytes, Pteridophytes and Gymnosperms	18+36+18	9+18+18	4
PG25BOI04	Research Methodology, Biostatistics and Biophysical Instrumentation	18+18+18	9+9+18	3
PG25BOP1	Practical of Microbiology and Phycology & Mycology and Crop pathology			2
PG25BOP2	Practical of Bryophytes, Pteridophytes and Gymnosperms & Research Methodology, Biostatistics and Biophysical Instrumentation			2

PG25BO101: MICROBIOLOGY AND PHYCOLOGY
(Theory 27 + 45 hrs; Practical 9 + 36 hrs; Credits 4)

COURSE OUTCOMES (CO)

CO No	EXPECTED COURSE OUTCOME Upon completion of this course, the students will be able to	Knowledge Level	PSO No
1	Understand microbial diversity, classification, and techniques for culture and isolation.	K2, K4	1,2
2	Explain viral classification, structure, replication and sub-viral entities.	K2	1
3	Understand algal classification systems, digital resources like AlgaeBase, and key research centers in India.	K2	1,2
4	Identify major algal groups, their phylogeny, and examine their reproduction methods and categorise their life cycle patterns.	K3	1,5
5	Discuss the ecological roles and economic importance of algae.	K4	4,6
6	Develop skills for collection, preservation, and culture of algae.	K3	2,5
Knowledge Levels: K1-Remembering; K2-Understanding; K3-Applying; K4-Analyzing; K5-Evaluating; K6-Creating			

MICROBIOLOGY (27 hrs)

Module 1 (17 hrs)

(a) History of microbiology, Koch‟s postulates, Diversity and classification of microbes (Three Domain system and Bergey‟s manual).

(b) Bacterial culturing methods, types of culture media, enrichment culture techniques, methods for isolating pure cultures, maintenance and preservation of pure cultures.

(c) Bacterial morphology. Classification of Bacteria according to Bergey‟s manual of systematic bacteriology.

(d) Ultra structure of Gram positive and Gram-negative bacteria; cell membrane, cell wall, flagella, pili, fimbriae, capsule and slime, ribosome and endospores.

(e) Major groups of Bacteria: Spirochetes, Rickettsias, Chlamydias, Mycoplasmas, Actinomycetes, Myxobacteria, Archaebacteria. Extremophiles - thermophilic, halophilic, acidophilic and alkalophilic bacteria.

(f) Nutritional types - Photolithotrophs, chemolithotrophs, photoorganotrophs, and chemoorganotrophs.

(g) Bacterial Genetics: Organization and replication of genetic material in bacteria - bacterial chromosome, plasmid. Recombination in bacteria - conjugation, transformation and transduction.

(h) General account on actinomycetes, mycoplasmas, chlamydiae, spirochaetes, Rickettsia and Deinococcus-Thermus

(i) Association with vascular plants: symbiotic nitrogen fixation- Rhizobium, stem nodulating rhizobia, actinorhizae, Agrobacterium.

Module 2 (10 hrs)

(a) Nomenclature and Baltimore classification (2008), distinctive properties of viruses, morphology of viruses. Capsid and envelopes (SARS COV-2).

(b) Structure of bacteriophages belonging to ‘T’ series. Ultra structure of TMV and HIV.

(c) Viral replication: Lytic and Lysogenic cycles - Lytic cycle in T even phages, lysogeny in lambda phage.

(d) Sub viral particles - prions, viroids, virusoid.

Practical (9 hrs)

1. Preparation and sterilization of various microbial culture media and inoculation.
2. Differential staining of bacteria using Gram stain.
3. Isolation of *Rhizobium* from root nodules.
4. Isolation of microbes from soil: Serial dilution - pour plate/spread plate method.
5. Streak out a bacterial culture on an agar plate and isolation of colonies.

6. Antibacterial assay - disc diffusion/agar well method.

References

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14. F H Kayser, K A Bienz, J Eckert, R M Zinkernagel. *Medical Microbiology.*
15. L R Haahelm, J R Pattison, R J Whitley. *Clinical virology.*

PHYCOLOGY (45)

Module 3 (9 hrs)

(a) Detailed study of the classification by F. E. Fritsch (1935).
(b) Brief account on the classification (Upto groups and divisions) by Edward Lee (2008).
(c) AlgaeBase: Digital Exploration of Algal Systematics (Brief account).
(d) Centers of algal research in India.

Module 4 (15 hrs)

(a) Habit, habitat and distribution of Algae, Major characteristics of Chlorophyceae, Xanthophyceae, Bacillariophyceae, Dinophyceae, Phaeophyceae and Rhodophyceae.
(b) Phylogenetic affinities of Cyanobacteria and Algae.
(c) Range of thallus structure and their evolution.
(d) Reproduction in algae: Different methods of reproduction, evolution of sex organs.
(e) Major patterns of life cycle and post fertilization stages in Chlorophyta, Xanthophyta, Phaeophyta and Rhodophyta.
(f) Fossil algae.

Module 5 (15 hrs)

(a) Ecological importance of Algae. Primary productivity. Algae in symbiotic association, Ultraviolet radiation absorption by algae.

(b) Algae as food, fodder, biofertilizer, medicine, industrial uses. Algae in experimental studies (SCP, Biofuel, Live feeds).
(c) Harmful effects of algae: Algal blooms, causative organisms, symptoms and toxins of major toxic algal blooms (Amnesic Shellfish Poisoning, and Paralytic Shellfish Poisoning). Cyanobacterial toxins.

Module 6 (6 hrs)

(d) Methods and techniques of collection, preservation and staining of Algae.
(e) Algal culture: Importance, methods; Algal culture media- Bold's Basal Medium, Erlanson's Medium, BG-11 Medium, Walne's Medium.

Practical (27 hrs)

1. Critical study of diagnostic features and identification based on morphological, anatomical and reproductive parts using clear whole mounts/sections of the following genera

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

(b) Chlorophyceae - *Chlamydomonas, Volvox, Cosmarium, Scenedesmus, Ecballocystis, Microspora, Cladophora, Pithophora. Coleochaete, Chaetophora, Trentepohlia, Oedogonium, Bulbochaete, Zygnema, Mougeotia, Ulva, Chaetomorpha, Codium, Caulerpa, Halimeda, Chara, Nitella.*

(c) Xanthophyceae – *Vaucheria.*

(d) Bacillariophyceae – *Pinnularia, Navicula, Fragilaria, Cyclotella*

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

(f) Rhodophyceac - *Batrachospermum, Gelidium, Portieria, Gracilaria, Polysiphonia.*

(g). Euglenophyceae- *Euglena, Trachelomonas*

2. Students are expected to collect and identify algae from different natural habitats or visit an Algal research station. Prepare and submit the report of the field work/research station visit for evaluation during the practical exam.

References

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24. Sangeetha, J., Thangadurai, D., Elumalai, S., & Thimmappa, S. C. (Eds.). (2021). Phycobiotechnology: biodiversity and biotechnology of algae and algal products for food, feed, and fuel. CRC Press.

PG25BO102: MYCOLOGY AND CROP PATHOLOGY

(Theory 36 + 36 hrs; Practical 36 + 18 hrs; Credits:4)

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome Upon completion of this course, the students will be able to	Knowledge level	PSO No.
01	Explain the general characters of fungi and outline the classification of fungi proposed by various mycologists	K2	1
02	Identify and classify fungi into their respective groups based on the mycelial structure and reproduction	K3, K4	1,2
03	Examine the interactions of fungi in nature and their significance	K4	1,6
04	Analyse the intricacies of plant – pathogen interactions	K4	2
05	Illustrate management strategies against plant diseases	K2	2
06	Identify common diseases of crop plants and suggest control measures	K3	5
Knowledge Levels: K1-Remembering; K2-Understanding; K3-Applying; K4-Analyzing; K5-Evaluating; K6-Creating.			

Mycology (36 hrs)

Module 1 (9 hrs)

Introduction and classification of fungi

a) Overview of true fungi and fungal analogues (stramenopilan fungi and protistan fungi). General characters of Fungi. Thallus organization, hyphal structure. Hyphal aggregations and modifications. Modes of nutrition, extracellular digestion. Fungal reproduction, spores and spore dispersal. Types of fruiting bodies in fungi. Heterothallism, Parasexuality. Fossil fungi. Mycological studies in India.

b) Principles of classification of fungi. Classification by C. J. Alexopoulos and Mims (1979). An outline of classification of true fungi according to "AFTOL" scheme (Hibbet et al, 2007) and Tedersoo et al (2018). Brief account of DNA barcoding in fungi.

Module 2 (18 hrs)

Thallus organization and reproduction in Fungi

Mycelial structure and reproduction of;

(a) Myxomycota – Acrasiomycetes, Hydromyxomycetes, Myxomycetes, Plasmodiophoromycetes.

(b) Mastigomycotina - Chytridiomycetes, Hyphochytridiomycetes, Oomycetes.

(c) Zygomycotina - Zygomycetes, Trichomycetes.

(d) Ascomycotina - Hemiascomycetes, Pyrenomycetes, Plectomycetes, Discomycetes, Laboulbeniomycetes, Loculoascomycetes.

(e) Basidiomycotina - Teliomycetes, Hyphomycetes, Gastromycetes.

(f) Deuteromycotina - Blastomycetes, Hyphomycetes, Coelomycetes.

Module 3 (9 hrs)

Fungal associations and their significance

(a) Symbionts – Lichens (Thallus structure, nutrition, reproduction, ecological and economic significance), Mycorrhiza, Fungus-insect mutualism.

(b) Parasites - Common fungal parasites of plants, humans, insects and nematodes.

(c) Saprophytes - Fungal decomposition of organic matter, coprophilous fungi, cellulolytic fungi, lignolytic fungi.

(d) Agricultural significance of Fungi - Mycoparasite, mycoherbicide.

Practical (36 hrs)

1. Critical study of the following types by preparing suitable micropreparations; *Stemonitis, Physarum, Saprolegnia, Phytophthora, Albugo, Rhizopus, Aspergillus, Penicillium, Pilobolous, Saccharomyces, Xylaria, Peziza, Phyllochora, Puccinia, Termitomyces, Pleurotus, Auricularia, Polyporus, Lycoperdon, Dictyophora, Geastrum, Cyathus, Fusarium, Alternaria, Pestalotia, Graphis, Parmelia, Cladonia, Usnea.*
2. Isolation of fungi from soil and water by culture plate technique.
3. Estimation of mycorrhizal colonization in roots.
4. Collection and identification of common field macrofungi and record using geotagged photographs (5 types).

References

1. C J Alexopoulos, M Blackwell, C W Mims (2007). *Introductory Mycology* (IV Edn). Wiley India Pvt. Ltd.
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3. L N Nair (2010). *Methods of microbial and plant biotechnology*. New Central Book Agency (P) Ltd.
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22. Walsh, T. J., Hayden, R. T., & Larone, D. H. (2018). *Larone's medically important fungi: A guide to identification*. John Wiley & Sons.

CROP PATHOLOGY (36 hrs)

Module 4 (14 hrs)

Introduction and Host-parasite interactions

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

b) Process of infection and pathogenesis: Penetration and entry of pathogen into host tissue – mechanical, physiological and enzymatic. Host-parasite interaction, enzymes and toxins in pathogenesis.

c) Defense mechanism in plants: Non-host resistance, horizontal resistance, vertical resistance b) Pre-existing defense mechanisms: structural and biochemical c) Post-Infection/Induced/Dynamic defense mechanisms: structural (cell wall defense structures, histological defense structures) and biochemical (Defense through Production of Secondary Metabolites, Pathogen elicitors, Hypersensitive defense reaction)

d) Transmission of plant diseases: Plant disease transmission by wind, water, seeds and vectors.

Module 5 (10 hrs)

Plant disease management

a) Prophylatic methods - Exclusion, eradication, and protection. b) Chemical means of disease control – common fungicides, antibiotics and nematicides. Pesticides, and bactericides. c) Biological means of disease control - (Pseudomonas, Trichoderma, Beauveria, PGPR, VAM); Control of fungal plant pathogens by Mycofungicides. d) Immunization of plants against pathogens – defense through plantibodies, induction of plant defenses by artificial inoculation with microbes or by treatment with chemicals e) Transgenic approaches to disease resistance.

Module 6 (12 hrs)

Common plant diseases in Kerala

a. Cereals: Rice - blast disease; Wheat - black rust disease.

b. Vegetables: Chilly - leaf spot; Okra - vein clearing disease; Tomato - Serpentine leaf miner.

c. Fruits: Banana - bacterial leaf blight; Mango - Anthracnose; Papaya – mosaic disease

d. Spices: Ginger - Fusarium wilt; Pepper - quick wilt; Cardamom - marble mosaic disease.

e. Oil seeds: Coconut - Grey leaf spot

f. Rubber - abnormal leaf fall.

g. Sugar yielding: Sugarcane - red rot

h. Beverages: Tea - blister blight; Coffee - rust.

Practical (18 hrs)

1. Make suitable micropreparations and identify the diseases mentioned with due emphasis on symptoms and causative organisms.

2. Isolation of pathogens from diseased tissues (leaf, stem and fruit) by suitable method.

3. Collection and preservation of specimens from infected plants. Submit 5 herbarium sheets / live specimens/ geotagged photo plate along with a brief report.

4. Culture media preparation and sterilization PDA/ Czapek dox‟s medium

References

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2. Agrios, G. N. (2005). *Plant pathology*. Elsevier.

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PG25BO103: BRYOPHYTES, PTERIDOPHYTES AND GYMNOSPERMS
(Theory 18+36+18; Practical 9+18+18; Credit 4)

COURSE OUTCOMES (CO)

CO No.	EXPECTED COURSE OUTCOME Upon completion of this course, the students will be able to	Knowledge Level	PSO No.
1	Classify bryophytes based on their morphological and anatomical characteristics, and evaluate their ecological significance and practical applications	K4, K5	1, 4
2	Compare the different lifecycle events in various bryophytes	K4	1
3	Comprehend the classification, origin, and evolution of Pteridophytes, and examine the diversity of extinct Pteridophytes.	K2, K3	1
4	Analyse the morphology and anatomy of living Pteridophytes and develop a comprehensive understanding of their reproductive strategies.	K3, K4	1
5	Comprehend the classification, origin, distribution and evolution of gymnosperms	K2	1
6	Analyze the morphology, internal structure, reproduction, and evolution of different gymnosperms	K4	1, 6
Knowledge Levels: K1-Remembering; K2-Understanding; K3-Applying; K4-Analyzing; K5-Evaluating; K6-Creating.			

BRYOPHYTES (18 hrs)

Module 1 (6 hrs)

Introduction and Economic importance of bryophytes

(a) General characters and Water relations - absorption and conduction, ectohydric, endohydric and myxohydric bryophytes.
(b) Concept of algal and pteridophytic origin of bryophytes
(c) Traditional and modern systems of classification (Rothmaler 1957, Goffinet *et al.*, 2008 & Söderström *et al*., 2016)
(d) Contributions of Indian Bryologists (Brief account)
(e) Ecological significance of bryophytes with special reference on environmental monitoring.
(f) Applied bryology: ecological uses, household uses, medicinal uses, horticultural uses.

Module 2 (12 hrs)

Thallus structure

I. A general account of morphological and anatomical features, reproduction, life history and evolution of;

(a) **Hepaticopsida** (Marchantiales, Jungermanniales)
(b) **Anthocerotopsida** (Anthocerotales)
(c) **Bryopsida** (Polytrichales)

II. Modern approaches in Bryology

(a) Brief account of the recent developments in molecular phylogenetics and DNA barcoding of bryophytes (brief study)
(b) Cultivation and conservation of bryophytes with special note on *In vitro* culture techniques of bryophytes (brief description only)

Practicals (9hrs)

1. Detailed study of the structure of gametophytes and sporophytes of the following genera of Bryophytes by suitable micropreparation:
   Marchantiales*:* *Targionia, Cyathodium, Marchantia, Dumortiera, Asterella*
   Jungermanniales*:* *Pallavicinia, Porella*
   Anthocerotales*:* *Anthoceros*
   Polytrichales*:* *Pogonatum*.
2. Students are expected to submit a report of field trip to bryophytes natural habitats to familiarize with the diversity of bryophytes.
3. Collection and identification of common bryophytes seen around you and record using geotagged photographs (minimum 5 types)

References

1. Kashyap S R (1932). *Liverworts of Western Himalayas and the Punjab plains* (Vol. I & II). Research Co. Publications.

2. Chopra R N, P K Kumar (1988). *Biology of Bryophytes.* Wiley Eastern Ltd.

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PTERIDOPHYTES (36 hrs)
Module 3 (9 hrs)

General introduction, Classification and Significance of Pteridophytes

Introduction, general characteristics and an outline of the classification of Pteridophytes (brief account of PPG system), Stelar organization, soral and sporangial characters of pteridophytes. Ecological and economic significance of Pteridophytes.

Origin and evolution of pteridophytes and brief study of extinct pteridophytes

(I) Psilopsida (a) Psilophyton
(II) Sphenopsida (a) Hyeniales (b) Sphenophyllales; *Sphenophyllum* (c) Calamitales; *Calamites*
(III) Pteropsida (i) Primofilicales (a) Cladoxylales; *Cladoxylon* (b) Coenopteridales.

Module 4 (27 hrs)

Structure of the plant body

Distribution, habitat, range, external and internal morphology of sporophytes, spores, mechanism of spore dispersal, gametophytic generation, sexuality, embryogeny of the following classes of Pteridophytes with reference to the genera mentioned (development of sex organs is not necessary):

(II) Psilotopsida (a) Psilotales; *Psilotum*
(III) Lycopsida (a) Lycopodiales; *Lycopodium*
(b) Isoetales; *Isoetes* (c) Selaginellales; *Selaginella*.
(d) Equisetales; *Equisetum.*
(ii) Eusporangiatae (a) Marattiales; *Angiopteris* (b) Ophioglossales; *Ophioglossum*.
(iii)Osmundales; *Osmunda*.
(iv) Leptosporangiatae (a) Salviniales; *Salvinia, Azolla* (b) Filicales; *Lygodium Acrostichum, Adiantum*.

Practical (18 hrs)

1. Study of morphology and anatomy of vegetative and reproductive organs using clear whole mounts/sections of the following genera:
Psilotum, Lycopodium, Isoetes, Selaginella, Equisetum, Angiopteris, Ophioglossum, Osmunda, Marsilea, Salvinia, Acrostichum, Adiantum, Lygodium.
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.

Reference

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2. Arnold, C.A., 2013. *An introduction to paleobotany*. Read Books Ltd.

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GYMNOSPERMS (18 HRS)

Module 5 (2 hrs)

Introduction and classification

a) General characteristics, distribution of Gymnosperms
b) Classification of gymnosperms (K R Sporne 1965 and Christenhusz et al., (2011)).
c) Distribution of living gymnosperms in India

Module 6 (16 hrs)

Vegetative and reproductive structures of Gymnosperms

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: *Glossopteris, Medullosa, Cycas, Zamia, Pentoxylon*.
- Class Coniferopsida: *Pinus, Cupressus, Podocarpus, Agathis, Araucaria, Taxus* and *Ginkgo.*
- Class Gnetopsida: *Gnetum.*

Gametophyte development and economic importance of Gymnosperms

- General account on the male and female gametophyte development in Gymnosperms (*Cycas*).
- Economic importance of Gymnosperms.

Practical (18 hrs)

1. Study of the morphology and anatomy of vegetative and reproductive parts of C*ycas, Zamia, Pinus, Cupressus, Agathis, Araucaria* and *Gnetum.*

2. Conduct field trips to familiarize various gymnosperms in nature and field identification of Indian gymnosperms and submit a report.

3. Field study to familiarize with the diversity of Gymnosperms in natural habitats/botanical garden; 5 geotagged photographs of Gymnosperms with identification should be recorded.

References

1. Andrews H N Jr (1961). Studies in Palaeobotany. John Wiley and sons.

2. Arnold C A (1947). An introduction to Palaeobotany. John Wiley and sons.

3. Beck C E (1995). Gymnosperm Phylogeny. Bot. Rev. 51-176.

4. Bhatnagar S P, Moitra A (2000). Gymnosperms. New Age International Ltd.

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PG25BOI04: RESEARCH METHODOLOGY, BIOSTATISTICS AND BIOPHYSICAL INSTRUMENTATION
(Theory: 18+18+18, Practical: 9+9+18, Credit: 3)

COURSE OUTCOMES (CO)

CO No.	EXPECTED COURSE OUTCOME Upon completion of this course, the students will be able to	Knowledge Level	PSO No.
1	Interpret basic concepts of research, its methodologies and significance	K2	4,5
2	Understand IPR and ethical issues in scientific research	K2	3,5
3	Develop the skills necessary to collect data, analyse statistically, interpret results and document findings.	K3	3,4,5
4	Utilize statistical tools for data interpretation in biological research.	K3	4,5
5	Explain the fundamental principles and diverse applications of different types of microscopes.	K3	2,5
6	Develop basic knowledge in analytical techniques and their applications in separation and quantification of plant metabolites	K4	3,4,5
Knowledge Levels: K1-Remembering; K2-Understanding; K3-Applying; K4-Analyzing; K5-Evaluating; K6-Creating.			

Research Methodology (18 hrs)

Module 1 (10 hrs)

a) Definition of Science and Research: Logical methods: Induction, Deduction, deductive-inductive process.

b) *Research Process*: critical thinking, theory, objectivity, reliability, validity.

c) Library Resources: Classification of books: Universal Decimal System and Dewey Decimal Classification. Journals: Indexing journals, abstracting journals, research journals, review journals: Impact factor, H-index.

d) Online Literature Search: Use of online search services like NCBI-PubMed and ScienceDirect (Hands-on session).

e) Plagiarism: Definition, types, detection software; publication ethics

f) Selecting and Defining a Research Problem: Critical literature review, identifying gap areas.

g) Formulation of Hypothesis: Testing of hypothesis: Null and alternate hypothesis.

h) Preparation of Research Plan: Classification of research (basic, applied, exploratory, descriptive, experimental).

i) Experimental designs: Principles – replication, local control and randomization.

Common designs in biological experiments: Completely randomized design, randomized block design, Latin square design, Factorial design

j) Project Proposal Preparation: Title, introduction, literature review, abstract, aim and scope, present status, location of experiments, materials and methods, justification, expected outcome, plan of action, estimated date of completion, budget preparation, references. Overview of national funding agencies supporting scientific research.

k) Structure of Scientific Papers: Research papers, review papers, dissertations.
l) Components of a Scientific Paper: Rules for title, abstract (structure and format), keywords, introduction, methodology, results, discussion, conclusion.
m) Style Manuals: APA, MLA, Chicago; Guidelines for formatting and referencing; Reference management software.

Module 2 (8 hrs)

a) Presentation: Preparation and organizing of science poster presentations and oral presentations.
b) Types of Scientific Events: Seminar, conference, colloquium, symposium, workshop
c) Overview of IPR: Copyright, patents, trademarks, geographical indications.
d) Laboratory Etiquettes: Safety and precautions, ISO standards for safety, accreditation of research labs (NABL)
e) Bioethics: Definition, major ethical issues in experimentation involving animals and humans.

Practical (9 hours)

1. Prepare a project proposal.
2. Prepare an outline of a dissertation and research paper.
3. Prepare a review based on a research theme.
4. Use online search literature services such as PubMed, Science direct.
5. Prepare a model project proposal and submit the same for evaluation.
6. Prepare a project proposal with the help of PowerPoint and submit the same for evaluation.

References

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5. Joseph G (2000). MLA Handbook for writers of research papers. Affiliated East West Press Pvt. Ltd.
6. Pruzan, P. (2016). Research methodology: the aims, practices and ethics of science. Springer.
7. Peat, J., Elliott, E., Baur, L., & Keena, V. (2013). Scientific writing: easy when you know how. John Wiley & Sons.
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9. Parija, S. C., & Kate, V. (Eds.). (2018). Thesis writing for Master's and Ph. D. program. Springer.
10. Lester, J. D., & Lester Jr, J. D. (2018). Writing research papers: A complete guide.

Biostatistics (18 hours)

Module 3 (8 hrs)

Introduction and Basic principles of Biostatistics

a) Methods of collection and classification of data; Primary and secondary data, qualitative and quantitative data.
b) Tabulation and presentation of numerical data- diagrammatic and graphical presentation.
c) Measures of central tendencies- mean, median and mode.
d) Measures of variations- range, quartile deviation, mean deviation- variance and standard deviation. Standard error and Coefficient of variation.
e) Data organisation, entry, preliminary data analysis and making different graphs using MS Excel.
f) Probability - Definition, mutually exclusive events – sum rule, independent events – product rule. Probability of unordered combination of events.
g) Applications of biostatistics.

Module 4 (10 hrs)

Essential Statistical Methodologies

I. Tests of significance

Tests of significance- f, z, t and $\chi 2$ tests. ANOVA

II. Correlation and Regression

Simple linear correlation- definition and utility, types, positive and negative correlation, scatter diagram and correlation graph, coefficient of correlation.

Simple linear regression- definition and utility, regression coefficient, comparison of correlation and regression.

III. Probability

Probability - Definition, mutually exclusive events - addition rule, independent events - multiplication rule, conditional probability, applications of probability. Standard probability distributions- definition, properties, and utilities of binomial distribution, poisson distribution and normal distribution

IV. Familiarise statistical tools

SPSS and R programming (brief study)

Practical (9 hrs)

1. Analysis of data to find the mean, median and mode using MS Excel.
2. Preparation of various graphs: Bar diagram with SD/SE using MS Excel.
3. Analysis of a given data for mean deviation and standard deviation.
4. Test the significance of a given data using t test, X^2 test, F-test and ANOVA.
5. Analysis of a set of data for correlation/regression.
6. Determine probability for different types of events.
7. Familiarization and data analysis using SPSS or any other apt software.

References

1. Alex Reinhart (2015). *Statistics Done Wrong*. No Starch Press.
2. Chandel R S (1975). *A handbook of Agricultural statistics*. Achal Prakashan Mandir.
3. Gomez K A, Gomez A A (1984). *Statistical procedures for agricultndural research*. John Wiley and Sons.
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8. Jerrold H. Zar (2014). Biostatistical Analysis Fifth Edition. *Pearson.*
9. Thomas Glover and Kevin Mitchell (2015). An Introduction to Biostatistics. Waveland Pvt. Inc. 2 edition.

Biophysical Instrumentation: (18 hrs)

Module 5 (8 hrs)

Microscopy

Parts of microscope, principles of microscopy. Types of microscopes - simple and compound; Stereo microscope, Phase contrast microscope, Fluorescence microscope and Electron microscope (TEM, SEM). Micrometry.

Module 6 (10 hrs)

(a) Fundamental principles of:

(i) UV-Visible spectrophotometer
(ii) Atomic Absorption Spectrophotometer
(iii) Nuclear Magnetic Resonance Spectrophotometer

(b) Principles and applications of Chromatography

(i) Column chromatography
(ii) High-performance liquid chromatography (HPLC)
(iii) HPTLC
(iv) LCMS
(v) GCMS

(c) Immunoassay systems:

(i) Radioimmunoassay (RIA)
(ii) Enzyme-linked immunosorbent assay (ELISA)

(d) Cryobiology- Lyophilisation and its applications
(e) Electrophoresis – Agarose Gel Electrophoresis, SDS-PAGE

Practical: (18 hrs)

1. Micrometry: Calibrate the ocular micrometer stage micrometer on a light microscope and measure the size of an object (e.g., diameter of spore/pollen grains, width of algal filaments).
2. Calibrate the pH meter and test the pH of different sample solutions.
3. Estimate the concentration of the given sample using calorimeter or spectrophotometer.
4. Prepare a plant extract and perform TLC.

References

1. Ackerman E A, Ellis L E E, Williams L E (1979). *Biophysical Science*. Prentice-Hall Inc.
2. Chang R (1971). *Basic principles of spectroscopy*. McGraw Hill.
3. Pesce A J, Rosen C G, Pasty T L. *Fluorescence Spectroscopy: An introduction for Biology and Medicine*. Marcel Dakar.
4. Stanford J R (1975). *Foundation of Biophysics*. Academic press.
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6. Perkampus H (1992). *UV-VIS Spectroscopy and its applications*. Springer-Verlag.
7. Garry D Christian, James E O‟reilvy (1986). *Instrumentation analysis*. Alien and Bacon,

Inc.
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10. Salle A J (1974). *Fundamental principles of Bacteriology*. McGraw Hill
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SEMESTER II

Course Code	Title	Teaching hrs Theory	Teaching hrs Practical	Credit
PG25BO205	Plant Anatomy and Microtechnique	36+36	27+27	4
PG25BO206	Cell Biology, Developmental Biology and Immunology	45+18+9	27+18	4
PG25BO207	Biotechnology, Bioinformatics and Bionanotechnology	54+18	27+9	4
PG25BO208	Ecology and Environmental Science	54	18	3
PG25BOP3	Practical of Plant Anatomy and Microtechnique & Cell Biology, Developmental Biology and Immunology			2
PG25BOP4	Practical of Biotechnology, Bioinformatics and Bionanotechnology & Ecology and Environmental Science			2

PG25BO205: PLANT ANATOMY AND MICROTECHNIQUE
(Theory 36 + 36 hrs; Practical 27 + 27 hrs; Credits 4)

COURSE OUTCOMES (CO)

CO No.	EXPECTED COURSE OUTCOME Upon completion of this course, the students will be able to	Knowledge Level	PSO No.
1	Understand the applications of plant anatomy in systematics, pharmacognosy, and research.	K2	1
2	Analyse the development, structure, and modifications of primary and secondary plant tissues.	K4	1
3	Examine floral, fruit, and seed anatomy in relation to development and function.	K3	1
4	Understand the principles of fixation, staining methods, and histochemical localization techniques for various cellular components.	K2	1, 2
5	Develop skill in dehydration, embedding, and sectioning techniques for preparing permanent slides.	K3	2, 5
6	Illustrate specimen preparations for electron microscopy and whole mount techniques	K2	2, 5
Knowledge Levels: K1-Remembering; K2-Understanding; K3-Applying; K4-Analyzing; K5-Evaluating; K6-Creating.			

Plant anatomy (36 hrs)

Module 1 (4 hrs)

(a) Scope and significance of plant anatomy, interdisciplinary relations. Research prospects in anatomy. Powder microscopy.

(b) Applications of anatomy in systematics (histotaxonomy) and Pharmacognosy. Research prospects in anatomy. Powder microscopy. Anatomy as a tool to identify adulteration.

Module 2 (25 hrs)

(a) Stages of development of primary meristem and theories of apical organization, origin of branches and lateral roots. Leaf: Initiation, ontogeny and structure. Primary thickening meristem (PTM) in monocots. Reproductive apex in angiosperms (brief study only).

(b) Vascular cambium and cork cambium: Structure and function, factors affecting cambial activity.

(c) Secondary xylem and phloem: Ontogeny, structure and function. Lignification patterns of xylem.

(d) Reaction wood: Compression wood and tension wood. Factors affecting reaction wood formation.

(e) Anomalous secondary growth in dicots and monocots (brief study only).

(f) Wood: Physical, chemical and mechanical properties.

(g) Plant fibers: Distribution, structure and commercial importance of coir, jute, and cotton.

(h) Structure, development and classification of stomata and trichomes. Krantz anatomy, anatomical peculiarities in CAM plants. Leaf abscission.

(i) Nodal anatomy: Unilacunar, trilacunar and multilacunar nodes, nodal evolution.

(j) Root-stem transition in angiosperms.

(k) Secretory tissues in plants: Structure and distribution of secretory trichomes (*Drocera*, *Nepenthes*), salt glands, colleters, Structure of bark and distribution pattern of laticifers in *Hevea brasiliensis*.

Module 3 (7 hrs)

(a) Floral Anatomy: Anatomy of floral parts - sepal, petal, stamen and carpel; Floral vasculature (*Aquilegia* and *Pyrola*). Vascular anatomy. Development of epigynous ovary - appendicular and receptacular theory.

(b) Fruit and seed anatomy: Anatomy of fleshy and dry fruits - follicle, legume, berry. Dehiscence of fruits. Structure of seeds. Anatomical factors responsible for seed dormancy and drought resistance.

Practical (27 hrs)

1. Study of cambia - non storied and storied.
2. Study the anomalous primary and secondary features in, *Amaranthus*, *Boerhaavia*, *Mirabilis*, *Nyctanthes*, *Piper* and *Strychnos*.
3. Study of stomata, trichomes, and laticifers. Determination of stomatal index.
4. Study the anatomical peculiarities of C4 and CAM plants (Leaf/Stem).
5. Study of nodal patterns.
6. Prepare a histotaxonomic key.
7. Study the pericarp anatomy of a legume, follicle and berry.
8. Identification of wood - soft wood and hard wood.
9. Comparative anatomy and powder microscopy of *Curcuma* sps

Reference

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2. Edred John Henry Corner (1976). The seeds of dicotyledons (vol. I, II). Cambridge University Press.
3. Ella Werker (1997). Seed Anatomy. Borntreager.
4. Elizabeth G Cutter (1978). Plant anatomy part I & II. Clive and Arnald Ltd.
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10. Chowdhuri (Ed). Indian woods (6 volumes). Forest research institute, Dehradun
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17. Reghu C P (2002). Structural features of Rubber wood. Rubberwood Processing and utilization in India.Ganesh Publications, Bangalore.
18. Reghu C P, George B P, YA Varghese (2007). Screening of Hevea germplasm for wood quality using Cinnamyl Alcohol Dehydrogenase (CAD) activity and lignifications pattern. Natural Rubber Research, 20 (1&2): 1-7.
19. Sherwin John Carlquist (2001). Comparative wood anatomy: Systematic, ecological, and evolutionary aspects of dicotyledon wood.
20. Tharian George K, Reghu C P, Nehru CR (2000). By-products and ancillary sources of income. Natural Rubber: Agro management and Crop Processing, Rubber Research Institute of India, Kottayam. 507-510
21. Vasishta P C (1994). Plant anatomy. Pradeep publications.
22. Wardrop A B (1961). The structure and formation of reaction wood in Angiosperm: Problems of tree physiology. Recent advances in Botany (Vol II). University of Toronto press.
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24. Kokatae C K, Purohit A P and Gokhale S B 2013 Pharmacognosy. Nirali Publications
25. The Ayurvedic Pharmacopoeia of India.

Microtechnique (36 hrs)

Module 4 (12 hrs)

(a) Principles and techniques of killing and fixing; properties of reagents, fixation images; properties and composition of important fixatives – Carnoy's Fluid, FAA, FPA, Chrome acetic acid fluids, Zirkle-Erliki fluid.

(b) Principles of staining; classification of stains, protocol for preparation of; (i) Natural stains - Haematoxylin and Carmine (ii) Coal tar dyes – Fast green, Orange G, Safranine, Crystal violet, Cotton Blue and Oil Red O.

(c) Techniques of staining: (i) Single staining; Staining with Safranine or crystal violet (ii) Double staining; Safranine-Fast green method, Safranine-Crystal violet method (iii) Triple staining; Safranine-Crystal violet-Orange G method.

Module 5 (12 hrs)

(a) Dehydration: Principles of dehydration, properties and uses of important dehydrating and clearing agents - alcohols, acetone, xylol, glycerol, chloroform, dioxan. Dehydration Methods: (i) Tertiary-butyl alcohol method (ii) Alcohol-xylol method.
(b) Embedding: Paraffin embedding.
(c) Sectioning: Free hand sections – Prospects and problems; Sectioning in rotary microtome - sledge microtome and cryotome.
(d) Mounting: Techniques, common mounting media used - DPX, Canada balsam, Glycerine jelly and Lactophenol. Cleaning, labeling and storage of slides.

Module 6 (12 hrs)

(a) Specimen preparation for transmission electron microscopy: Material collection, fixing, dehydration, embedding, sectioning (glass knife preparation, grid preparation, ultra microtome) and staining.
(b) Whole mounts: Principles and techniques of whole mounting, TBA/Hygrobutol method, Glycerine-xylol method. Staining of whole mount materials (haematoxylin, fast green or Safranine-fast green combination). Significance of whole mounts.
(c) Techniques of smear, squash and maceration.
(d) Histochemical localization of starch, protein, lipid and lignin.

Practical (27 hrs)

1. Students are expected to be thorough with the following techniques.
(a) Preparation of semi-permanent slides.
(b) Preparation of permanent slides.
(c) Preparation of whole mounts.
(d) Maceration.
(e) Preparation of fixatives (FAA, Carnoys‟fluid).
(f) Preparation of dehydration series (Alcohol, Acetone, TBA).
(g) Preparation of paraffin blocks.
(h) Preparation of serial sections.
2. Students should prepare and submit 5 permanent slides in which the following categories should be included:
(a) Free hand sections (single/double stained).
(b) Serial sections (single/double stained).
(c) Wood sections and whole mounts.

References

1. Johanson D A (1940). *Plant microtechnique*. McGraw Hill co.
2. John E Sass (1967). *Botanical Microtechnique*. Oxford IBH Publ. Company.
3. Gray (1964). *Handbook of Basic Microtechnique*. McGraw Hill co.
4. Prasad M K, M Krishna Prasad (1983). *Outlines of Microtechnique*. Emkay Publications.
5. Geoffrey A Meek (1976). *Practical electron microscopy*. John Willey and sons.
6. Krishnamurthy K V (1987). *Methods in Plant Histochemistry*. S Viswanathan printers, Anand book depot, Madras.
7. Toji Thomas (2005). *Essentials of botanical microtechnique* (II Edn). Apex infotech publishing company.

PG25BO206: CELL BIOLOGY, DEVELOPMENTAL BIOLOGY AND IMMUNOLOGY

(Theory 45+18+9; Practical 27+18; Credits 4)

COURSE OUTCOME (CO)

CO No.	EXPECTED COURSE OUTCOME Upon completion of this course, the students will be able to	Knowledge Level	PSO
1	Explain the structure and function of basic components of eukaryotic cell, cytoskeleton, endomembrane system and protein trafficking	K2	2
2	Understand how the cells interact among themselves and with the environment through signal molecules.	K2	2
3	Gain in-depth understanding of the cell cycle, cancer development, and programmed cell death	K2, K4	2
4	Understand angiosperm reproduction and seed formation processes.	K2	2
5	Explore plant development, focusing on key genes and processes like embryogenesis and flowering.	K4	1
6	Understand the immune system, including its components, mechanisms, regulation, and clinical implications in health and disease.	K2	2
Knowledge Levels: K1-Remembering; K2-Understanding; K3-Applying; K4-Analyzing; K5-Evaluating; K6-Creating.			

CELL BIOLOGY (45 hrs)

Module 1: (15 hrs)

Intracellular Architecture & Cytoskeleton in Eukaryotic Cells

I. Major intracellular compartments in eukaryotic cells (brief study only)

II. Structural organization of cell membranes:
   a) Chemical composition
   b) Membrane functions.
   c) Transport of molecule across cell membrane:
      i) Simple diffusion – factors affecting diffusion
      ii) Facilitated diffusion - Carrier proteins, properties of carrier proteins, uniport, antiport and symport
      iii) Channel proteins – ion channels, porins and aquaporins
      iv) Active transport – ATPases – P type, F type, V type and ABC type.

III. Endomembrane system
   a) The endoplasmic reticulum: smooth and rough endoplasmic reticulum, synthesis of proteins on membrane-bound and free ribosomes and processing.
   b) The Golgi complex: glycosylation, movement of materials through the Golgi complex.
   c) Types of vesicle transport and their functions.
   d) Peroxisomes
   e) Targeting of proteins to mitochondria, chloroplasts and peroxisomes.

IV. Cytoskeleton

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

Module 2: (15 hrs)
Cell communication and Cell signalling

(a) Cell communication: general principles. Signalling molecules and their receptors, external and internal signals that modify metabolism, growth, and development of plants.

(b) Receptors: Cell surface receptors – ion-channel linked receptors, G-protein coupled receptors, and Tyrosine-kinase linked receptors (RTK), Steroid hormone receptors.

(c) Signal transduction pathways, Second messengers, Regulation of signalling pathways. Bacterial and plant two-component signalling systems.

Module 3: (15 hrs)
Cell cycle, Cancer and Apoptosis

I. Cell cycle an overview
   a) Phases of cell cycle.
   b) Cell cycle checkpoints: DNA damage checkpoints, Spindle assembly checkpoint
   c) Working mechanism of cell cycle checkpoints: Cyclin Dependent Kinases – key features, types of CDK, Cyclins - key features, types of cyclins
   d) Regulation of CDK Activity: Cyclin level, CDK-activating kinase, Inhibitory phosphorylation, CDK Inhibitors

II. Cancer and apoptosis
   a) Types of cancer
   b) Properties of cancer cells
   c) Oncogenes and proto-oncogenes
   d) Functions of proto- oncogene; Tumor- suppressor genes and their normal functions
   e) Apoptosis: Mechanism of programmed cell death
   f) Extrinsic pathway and Intrinsic pathways
   g) Role of caspases in amplifying apoptotic signals
   h) Role of mitochondria in regulating apoptosis
   i) Pro-apoptotic proteins Bax and Bak and their interaction with outer mitochondrial membrane
   j) Inhibitors of apoptosis.

Practical (27 hrs)

a) Identification of different stages of meiosis from suitable plant material. Record the photographs of each stage.
b) Identification of different stages of mitosis and study of morphology of metaphase chromosomes from Onion root meristems.
c) Study of mitotic index from suitable plant material.

References

1. Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, Peter Walter (2014). Molecular biology of the cell (VI Edn). Garland Science, Taylor and Francis group.
2. Gerald Karp (2013). Cell and Molecular biology: Concepts and experiments (VII Edn). John Wiley &Sons.

3. Harvey Lodish, Arnold Berk, Lawrence Zipursky, Paul Matsudaira, David Baltimore, James Darnell (2016). Molecular cell biology (VIII Edn). W H Freeman & Company.
4. Geoffrey M Cooper, Robert E Hausman (2013). The Cell: A molecular approach (VI Edn). Sinaeur.
5. Wayne M Becker, Lewis J Kleinsmith, Jeff Hardin (2012). The world of the cell (VIII Edn). Pearson
6. D Peter Snustad, Michael J Simmons (2012). Principles of genetics (VI Edn). John Wiley and Sons.
7. Robert J Brooker (2023). Genetics: analysis and principles (VI Edn). McGraw Hill.
8. Benjamin A Pierce (2012). Genetics: A conceptual approach (IV Edn). W H Freeman and Company.
9. Burtton E Tropp (2012). Molecular biology; from genes to proteins (IV Edn).

Developmental Biology (18 hrs)

Module 4 (12 hrs)

(a) Anther: Structure and development, microsporogenesis, male gametophyte development, Palynology: Pollen morphology, exine sculpturing, pollen kit, NPC formula. Applications of palynology - palynology in relation to taxonomy. Viability of pollen grains. Pollination, pollen germination, growth and nutrition of pollen tube.

(b) Ovule: Structure, ontogeny and types. Megasporogenesis. Embryosac development, types, ultrastructure, and nutrition of embryosac, Female gametophyte development

(c) Fertilization: Double fertilization; embryo development - different types of Endosperm development, types of endosperms, haustorial behavior of endosperm, Xenia and metaxenia.

(d) Polyembryony – types and causes

(e) Seed formation, dormancy and germination, Apomixis, Parthenogenesis,

Module 5 (6 hrs)

(a) Introduction to model plants used for development studies in plant system, advantages of each system with special emphasis on model plant Arabidopsis

(b) Origin of polarity, Function of Auxin during embryogenesis, Genes essential for embryo formation (GURKE, FACKEL, GNOM, MONOPTEROS), Radial patterning in plants and the genes involved in it (ATML1, PDF2, CRE or WOL)

(c) Shoot and root development. Leaf development and Phyllotaxy.

(d) Transition to flowering, floral meristems and floral development.

(e) Homeotic genes in plants. Senescence, programmed cell death and hypersensitive response in plants.

Practical (18 hrs)

1. Study of pollen morphology.
2. Embryo excision from young seeds.
3. Study of pollen germination using cavity slide.
4. Identification of different types of embryos, polyembryony, endosperm types, types of pollen grains, anther growth stages and types using permanent slides.

Reference

1. Bewley J. D. and Black, M. (1994). *Seeds: Physiology of Development and Germination*. Plenum Press.
2. Bhattacharya, K., Majumdar, M. R. and Bhattacharya, S. G. (2006). *A Textbook of Palynology*. New Central Book Agency Pvt. Ltd., Kolkata
3. Bhojwani, S. S. and Bhatnagar, S. P. (2000). *The Embryology of Angiosperms*. Vikas Publishing House.
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5. Clement, C., Pacini, E. and Audran, J. C. (1999). *Anther and Pollen – from Biology to Biotechnology*, Springer.
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7. Faegri, K. and Iversen, J. (1989 (also reprinted in 2000)). *Textbook of Pollen Analysis*, 4th Ed. Blackburn Press, Caldwell, NJ.
8. Lincoln, Taiz and Eduardo, Zeiger. (2002). *Plant physiology* (IIEdn). Sinaeur Associates, Inc. Publishers.
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13. Scott, F. Gilbert. (2000). *Developmental Bilogy* (IX Edn). Sinauer Associates.

IMMUNOLOGY (9 hrs)

Module 6 (9 hrs)

a) Innate and acquired immunity.

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

c) Antigen-antibody interactions Antigen processing and presentation

d) Activation and differentiation of B cells – formation, role

e) T cells – types, roles, T cell receptors

f) Primary and secondary immune modulation, complement system

g) Pattern recognition receptors – toll-like receptors

h) MHC molecules.

References

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PG25BO207: BIOTECHNOLOGY, BIOINFORMATICS AND BIONANOTECHNOLOGY
(Theory 54 + 18 hrs; Practical 27 + 9 hrs; Credits: 4)

COURSE OUTCOMES (CO)

CO No.	EXPECTED COURSE OUTCOME Upon completion of this course, the students will be able to	Knowledge Level	PSO
1	Understand microbial and plant biotechnology techniques for metabolite production and tissue culture	K2	1,2
2	Explain gene cloning, recombinant DNA technology, and their applications	K2	3,4
3	Examine the significance of molecular techniques like PCR, blotting, and DNA sequencing in biological techniques	K4	3,4
4	Assess ethical, legal, and environmental aspects of biotechnology	K5	6
5	Understand biological databases, sequence alignment, molecular phylogeny, and protein structure prediction	K2	2,3
6	Apply concepts and techniques of bio nanotechnology in agriculture, medicine, and the environment	K3	3,4
Knowledge Levels: K1-Remembering; K2-Understanding; K3-Applying; K4-Analyzing; K5-Evaluating; K6-Creating.			

BIOTECHNOLOGY (54 hrs)

Module 1 (19hrs)

(a) Introduction to classical and modern biotechnology

(b) Microbial biotechnology: Commercial production of metabolites using bioreactors, Submerged and solid-state fermentation, Microbes in production of enzymes, antibiotics, biopolymers, bioethanol, organic acids, SCP, Microbial oxidative transformations.

(c) Plant biotechnology: Brief history and important milestones in plant tissue culture, General composition of the tissue 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 and hardening.

(d) Types of tissue culture: organized structures - meristem, shoot tip, node, embryo, root cultures, unorganized structures - callus, suspension and protoplast cultures.

(e) Cytodifferentiation and morphogenesis: Cellular totipotency, Differentiation of cells in callus - tracheid formation, chloroplast differentiation, Factors influencing vascular differentiation, Organogenic differentiation: factors influencing shoot bud differentiation, induction of organogenic differentiation.

(f) Propagation in vitro: Techniques and stages of micropropagation, Advantages and disadvantages of micropropagation, Applications of tissue culture.

Module 2 (16 hrs)

(a) Basic principles, tools and techniques: Restriction endonucleases – naming, types and reaction. Ligases – reaction, methods of blunt end joining - linkers and adaptors, Vectors – necessary properties of a vector, shuttle vectors, expression vectors. Construction and specific uses of plasmid, phage, cosmid, and artificial chromosomes, Creation of recombinant DNA. Methods of screening and selection of recombinant cells – selectable markers, reporter systems – Lac Z system, GFP.

(b) Procedure of gene cloning (in bacteria using pBR322 vector system): Isolation and purification of vector and the DNA to be cloned, creation of recombinant vector, introduction of recombinant DNA into host cell – preparation of competent host cells, transformation. Selection of transformed cells, identification of recombinant cells – insertional inactivation, Expression of foreign genes in host cells

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

Module 3 (15 hrs)

(a) Advanced tools and techniques: cDNA synthesis, artificial DNA synthesis (brief study), Construction of genomic and cDNA library.

(b) PCR - Procedure and applications, variants of PCR - Real time PCR and its applications, Automated DNA sequencing.

(c) In vitro mutagenesis and its application.

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

(e) Procedure and applications of DNA profiling, Foot printing, Procedure and applications of ELISA, RIA, Immunoprecipitation, flow cytometry, FISH, GISH, PFGE.

Module 4 (4 hrs)

Need for regulation, regulatory agency in India – GEAE. Patents – issues relating to patenting living organisms, their genes and other bioresources Potential impact of GMOs on the ecosystem GM food – effect on health and environment. Ethical problems of rDNA technology, Economic issues, Potential misuse of modern molecular biology tools and techniques, bioweapons, bioterrorism

Practical (27 Hrs)

1. Preparation of the stock solutions of MS medium.
2. 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. Production of amylase by solid state and submerged fermentation.

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BIOINFORMATICS (9 hrs)

Module 5 (9hrs)

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

(b) Molecular Phylogeny: molecular clock hypothesis. Phylogenetic Trees, Terminology in Phylogenetic tree. Tree drawing Methods. Cladogram and Phylogram. Significance of Molecular Phylogeny.

(c) Structural Bioinformatics: Molecular structure viewing tool – Rasmol; Protein structure prediction – Secondary Structure prediction (Chou Fasman method), Tertiary structure prediction (Homology modelling).

Practical (4hrs)

1. Multiple sequence alignment using MEGA.
2. Creation of phylogenetic trees using MEGA/RaxML.
3. Calculate the genetic distance (K_2P) using MEGA.

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BIO NANOTECHNOLOGY (9 hrs)

Module 6 (9 hrs)

Introduction to nanoparticles and nanotechnology

(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.

(b) Applications of bio nanotechnology

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 (5hrs)

1. Synthesis of nanoparticles utilizing plant extracts.
2. Characterisation of nanoparticles using UV-visible spectrophotometer and XRD.

References

1. Rohela, G. K., Srinivasulu, Y., & Rathore, M. S. (2019). A review paper on recent trends in bio-nanotechnology: Implications and potentials. *Nanoscience & Nanotechnology-Asia, 9*(1), 12-20. https://doi.org/10.2174/2210681208666171204163015

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PG25BO208: ECOLOGY AND ENVIRONMENTAL SCIENCE

(Theory 54 hrs; Practical 18 hrs; Credits 3)

COURSE OUTCOME

CO No.	EXPECTED COURSE OUTCOME Upon completion of this course, the students will be able to	Knowledge Level	PSO No
1.	Understand key ecological principles, apply them in various fields, and explore population ecology.	K2, K3	5,6
2.	Identify the different types of ecosystems, components and their interrelationships.	K3	5,6
3.	Identify the causes, types, and impacts of environmental pollution, and evaluate methods for prevention and control.	K3, K5	4,5
4.	Explain the classification, management, and sustainable use of natural resources, remote sensing and its applications.	K2, K3	2,3,4
5.	Analyze the causes and effects of global warming and climate change and explore international efforts to mitigate climate change.	K4	6
6.	Understand the importance of biodiversity, consequence of biodiversity loss, and explain conservation strategies.	K2	1,6
Knowledge Levels: K1-Remembering; K2-Understanding; K3-Applying; K4-Analyzing; K5- Evaluating; K6-Creating			

ECOLOGY

Module 1 (8 hours)

(a) Definitions, history and scope of ecology, sub divisions of ecology, ecology vs environmental science. Interdisciplinary nature of environmental science

(b) Interdisciplinary aspects of ecology, applications of ecology in different fields (EIA, research, education, agriculture, healthy life, etc.)

Population ecology: Characteristics of populations; Population growth - factors affecting population growth, k-selection and r-selection populations; concept of metapopulation-demes and dispersal, interdemic extinctions. Population interactions; Positive and negative interactions, Lotka- Voltera predator–prey model.

Genecology - ecological amplitude, ecads, ecotypes, ecospecies, coenospecies.

Module 2 (10 hrs)

Community Ecology: Definition and concept, community characteristics; Community interdependence, Ecotone and Edge effect.

Characters used in the study of community structure – analytical and synthetic characters. Methods of study of community: quadrat, transect, sampling plots.

Diversity indices - Simpson's index, Shannon-Weiner's index, Sorenson’s similarity index.

Habitat and Niche: Concept of habitat and niche; niche width and overlap; fundamental and realized niche; resource partitioning; character displacement.

Succession: Definition and reasons of succession. Classification of succession: Changes - autogenic and allogenic, primary and secondary, autotrophic and heterotrophic, concept of climax or stable communities.

Ecosystem ecology: Ecosystem structure and function, ecosystem services. Energy flow and nutrient cycling in ecosystem. Primary and secondary productivity, trophic level, food chains, food webs, ecological pyramids.

Biogeography: Major terrestrial biomes; theory of island biogeography; biogeographical zones of India.

ENVIRONMENTAL SCIENCE

Module 3 (10 hrs)

Definition and classification.

(a) Water pollution: Water quality parameters and standards, 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. Microplastics in water sources. Case studies with respected to major rivers in India.

(b) 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. Case studies with respected to major cities in India.

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

Module 4 (10 hrs)

Natural resources: Concept of resource, classification of natural resources-renewable and non-renewable resources. Factors influencing resource availability, distribution and uses. Ecological footprint and Carbon footprint

Natural resource management and sustainable development: Sustainable use of natural resources – Resource management- meaning and concept.

Sustainable forest management; Watershed management: Rain water harvesting and storage, recharging ground water; Reclamation & Management of waste lands, soil conservation; Renewable and Alternative Energy Sources

Sustainable development goals (SDG) of the UN. (Brief account)

Environmental monitoring: Remote sensing and GIS- introduction, principle, application of remote sensing.

GIS in natural resource mapping, disaster mapping and biodiversity conservation (brief account).

Environmental impact assessment (EIA): EIA guidelines 1994, EIA methods; Environmental audit, ISO-14000 (Brief account).

Environmental biotechnology and waste management: Bioremediation, Phytoremediation, bioaugmentation, biofilms, biofilters, bioscrubbers and trickling filters.

Use of bioreactors in waste management.

Module 5 (8 hrs)

Global warming: Causes and impact, green-house gases and their sources, acid rain, ozone layer depletion, sea level rise, global climate change, desertification and habitat loss.

Effects of increased CO_2 on plants, carbon sequestration.

Climate change: Drivers of climate change, *El-Nino* and *La Nina* phenomenon and its consequences.

Implications on climate, oceans, agriculture, natural vegetation, wildlife and humans.

International efforts to mitigate climate change: IPCC, UNFCC, CoP, Paris Protocol,

Kyoto Protocol, Vienna agreement, Montreal protocol (Brief account).

Ecosystem resilience: Resilience and stability of ecological systems, resilience of terrestrial ecosystems, regime shift, resilience and biodiversity in ecosystem management.

Module 6 (8 hrs)

Definition, importance and levels of biodiversity.

Concept of endemism, rare, endangered and threatened species (RET), key stone species. Biodiversity hotspots

Biodiversity prospecting and indigenous knowledge systems, community biodiversity registers.

Biodiversity as bio resources – use and values (consumptive and productive use values) of biodiversity.

Threats of biodiversity: Causes of biodiversity loss and extinction - deforestation, habitat loss, industrialization, hunting and bio invasions; invasive species. Extinction through geological time scale: mass extinctions. Current extinction trends.

Conservation strategies: In-situ and ex-situ conservation method; Protected areas network, Wildlife conservation projects. People's participation in biodiversity conservation (JFM).

Role of biotechnology in conservation of species.

Conservation efforts: UNESCO- biosphere reserves, world heritage sites; IUCN and conservation, Red Data Book and categories.

Practical (27 hrs)

1. Analysis of water quality for; (a) Dissolved CO2 (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 chloride ions, dissolved sulphate, nitrate 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).
7. Students should be aware of the common environmental problems, their consequences and possible solutions.

References

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SEMESTER III

Course Code	Title	Teaching hrs theory	Teaching hrs practical	Credit
PG25BO309	Plant Physiology and Biochemistry	45+27	36+27	4
PG25BO310	Genetics, Plant Breeding and Horticulture	36+18+18	36+9+9	4
PG25BO311	Angiosperm Taxonomy, Economic Botany and Ethnobotany	63+9	63	4
PG25BO312	Molecular Biology	54	27	3
PG25BOP1	Practical of Plant Physiology and Biochemistry & Genetics, Plant Breeding and Horticulture			2
PG25BOP2	Practical of Angiosperm Taxonomy, Economic Botany and Ethnobotany & Molecular Biology			2

PG25BO309: PLANT PHYSIOLOGY AND BIOCHEMISTRY
(Theory 45 + 27 hrs; Practical 36 + 27 hrs; Credits 4)

COURSE OUTCOMES (CO)

CO No.	EXPECTED COURSE OUTCOME Upon completion of this course, the students will be able to	Knowledge Level	PSO No.
01	Explain nutrient uptake, transport and assimilation in plants	K2	2
02	Examine energy capture, conversion, and regulation in photosynthesis and respiration.	K4	2,4
03	Illustrate hormonal and environmental control of plant growth and morphogenesis and plant responses to abiotic stress	K4	2
04	Classify and compare the structure of biomolecules	K2, K4	2
05	Analyse the structure of enzymes and the mechanism of action	K4	2
06	Explain the biosynthesis and function of secondary metabolites and apply in systematics and research	K3	2
Knowledge Levels: K1-Remembering; K2-Understanding; K3-Applying; K4-Analyzing; K5-Evaluating; K6-Creating.			

Plant Physiology (45 hrs)

Module 1 (7 hrs)

(a) Absorption of nutrients: Soil characters influencing nutrient availability – size and charge of soil particles, soil pH. Entry of minerals into roots; bulk flow, diffusion. Role of Mycorrhizae in nutrient uptake.

(b) Nitrogen fixation, mechanism of biological nitrogen fixation, mechanism of root nodule formation- role of signals and phytohormones

(c) Nitrate assimilation, ammonium assimilation, transported forms of nitrogen

(d) Sulfur assimilation

(e) Phosphate assimilation

Module 2 (26 hrs)

i) Photosynthesis

(a) Action spectra and absorption spectra, light harvesting complexes – PSI and PS II, antenna pigment molecules, structure of reaction center, basic principles of light absorption, conversion of light energy to chemical energy.

(b) Photosynthetic apparatus; structure of chloroplast, thylakiod and arrangement of photosystem components, Z scheme, water splitting complex; structure and function, Structure and function of D1 protein, Uncouplers and other and other thylakoid electron transport inhibitors.

(c) Chemiosmotic hypothesis, photophosphorylation; cyclic and noncyclic, structure and functioning of CFO-CF1 complex, photosynthetic quantum yield and energy conversion efficiency.

(d) Repair and regulation of photosynthetic machinery; excess energy dissipation; non photochemical quenching, photoinhibition, xanthophyll cycle; scavenging system; role of carotenoids, superoxide dismutase, ascorbate.
(e) Calvin-Benson cycle, structure and function of Rubisco
(f) Regulation of Calvin-Benson cycle; Rubisco activation, ferredoxin –thioredoxin system, ion movement mediated modulation of regulation of Calvin-Benson cycle enzymes, light controlled assembly of chloroplast enzymes into supramolecular complexes
(g) C2 cycle and its significance
(h) CO_2 concentration mechanisms: C4 pathway, CAM pathway
(i) Synthesis of starch and sucrose
(j) Photosynthetic response to temperature and carbon dioxide
(k) Translocation of sugars sieve elements, types of companion cells and their role, source and sink, materials translocated in the phloem, phloem loading and unloading, transport of signalling molecules through phloem

ii) Respiration

(a) Glycolysis and citric acid cycle
(b) Gluconeogenesis
(c) Mitochondrial electron transport and ATP synthesis – structure of electron transfer complexes (complex I – IV), ATPase – detailed structure of F1 and Fo subunits, binding change mechanism of ATP synthesis, transport of NADH from cytoplasm to mitochondria-malate aspartate shuttle, glycerol-3-phosphate shuttle, Comparison of mitochondrial and chloroplast ATP synthesis, Cyanide resistant pathway – alternative oxidase, its regulation and significance

Module 3 (12 hours)

i) Sensory photobiology

(a) Structure, function and mechanisms of action of phytochromes, phytochrome mediated plant responses. Photoperiodism and biological clocks – circadian rhythms, Floral induction and development
(b) Blue light response, function and mechanisms of action of cryptochromes, phototropins, Zeitlupe (ZTL)

ii) Plant Growth Regulators

Biosynthesis, storage, breakdown, transport, physiological effects, and mechanism of action of plant growth hormones, elicitors

iii) Abiotic stress response

Water stress – deficit and flooding; Salinity stress; High temperature stress, low temperature stress – chilling and freezing; Heavy metal toxicity;
Mechanisms of tolerance to abiotic stresses

Practical (36 hrs)

1. Measurement of Photosynthesis - Hill Reaction.
2. Estimation of proline in plant tissues under various abiotic stresses.
3. Estimation of phenol in plant tissues affected by biotic stress.
4. Determination of peroxidase activity in plant tissues affected by biotic/abiotic stresses.

5. Estimation of free amino acids in senescing leaves to understand the source to sink transformation phenomenon.
6. Determination of osmotic potential by tissue weight method.
7. Separation of photosynthetic pigments by TLC/paper chromatography and calculating the Rf value
8. Demonstration of amylase activity and GA effect in germinating cereal seeds.
9. Estimation of total chlorophyll and study of absorption pattern of chlorophyll solution.
10. Separation and collection of leaf pigments by silica gel column chromatography.
11. Determination of nitrate reductase activity.
12. Extraction and estimation of leghaemoglobin from root nodules.

Reference

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12. S Sadasivam, A Manickam (1996). Biochemical methods (II Edn). New age international Publishers.

Biochemistry (27 hrs)

Module 4 (14 hrs)

i) Water and its effects on dissolved biomolecules

Structure and properties, unusual properties of water due to hydrogen bonding, Acids and bases, strength of acids and bases, ionization of water, Kw, pH, measurement methods,

dissociation of acids, pKa, Henderson-Hasselbalch equation,buffers, buffer action, buffer capacity

ii) Carbohydrates

Monosaccharides, classification, structure, isomerism, Disaccharides, structure, Polysaccharides, classification, structure, function, sugar derivatives

iii) Lipids

Classification, properties, function, structure of fatty acids, storage lipids and structural lipids, beta oxidation

iv Aminoacids

Structure and classification, nonstandard aminoacids, titration curve of amino acids, Shikimate pathway

v) Proteins

Classification and functions, Structural levels, Primary structure -peptide bond, Secondary structure – Ramachandran plot, α-helix, β-sheets, tertiary structure- forces that stabilize tertiary structure, quaternary structure, domains, motiff and folds, protein sequencing

Module 5 (9 hours)

(a) IUB system of enzyme classification and naming, general characters of enzyme, principle of enzyme action, mechanism of enzyme action – formation of Enzyme substrate complex,

(b) Formation of ES complex, acid-base catalysis, covalent catalysis, metal ion catalysis, proximity and orientation effect, strain and distortion theory. Factors affecting, enzyme activity

(c) Enzyme Kinetics: Michaelis-Menton kinetics, Lineweaver-Burk plot, Mechanism of multi substrate reaction – Ping Pong, Bi-Bi mechanism,

(d) Regulation of enzyme activity: Allosteric effect, control proteins, reversible covalent modification, proteolytic activation, Enzyme inhibition – reversible and irreversible inhibition, competitive, non-competitive, uncompetitive inhibition, dixon plot

(e) Cofactors and coenzymes: Essential ions, Coenzymes; structure and role of metabolite coenzymes – ATP; structure and role of vitamin derived coenzymes – NAD+, NADP+, FAD, FMN, TPP, PLP, Biotin, Isozymes and Abzymes

Module 6: (4 hours)

Secondary metabolites: Classification, role in growth, development and defense; terpenes, phenolic compounds, flavonoids- anthocyanins, anthocyanidins, flavones and flavonoids. Nitrogen containing compounds - alkaloids, cyanogenic glycosides, glucosiolates, nonprotein amino acids.

Practical (27 hrs)

1. Preparation of buffers of various strength and pH.
2. Preparation of molal, molar, normal and percentage solutions and their dilutions.
3. Quantitative estimation of reducing sugar using Dinitro salicylic acid (DNS) or Anthrone.
4. Separation and analysis of lipids and amino acids by TLC.
5. Quantitative estimation of protein by Lowry’s method.
6. Estimation of total phenolics.
7. Isolation and assay of amylase enzyme from germinating seeds/appropriate plant material

8. Estimation of peroxidase activity.
9. Estimation of catalase activity.

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PG25BO310: GENETICS, PLANT BREEDING AND HORTICULTURE

(Theory 36+18+18; Practical 36+9+9; Credits:4)

COURSE OUTCOMES (CO)

CO No.	EXPECTED COURSE OUTCOME Upon completion of this course, the students will be able to	Knowledge Level	PSO
1	Analyze genetic principles, inheritance patterns, chromosome mapping, and sex determination	K4	2,3
2	Apply genetic principles to analyze human inheritance patterns, identify genetic disorders and cancer	K3, K4	3
3	Understand the different types of mutations and principles of population genetics	K2	5
4	Apply plant breeding principles and hybridization methods in improving crop productivity	K3	2,3
5	Analyse the role of plant breeding for crop improvement	K4	3,4
6	Develop skills in horticulture techniques and analyse their applications	K3, K4	6
Knowledge Levels: K1-Remembering; K2-Understanding; K3-Applying; K4-Analyzing; K5-Evaluating; K6-Creating.			

GENETICS (36 hrs)

Module 1 (10 hrs)

a) 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).

b) Linkage, crossing over and chromosome mapping in eukaryotes. Cytoplasmic inheritance, multiple alleles, quantitative inheritance, QTL; Penetrance and expressivity, Sex determination in plants and animals, X chromosome inactivation in mammals – dosage compensation.

Module 2 (12 hrs)

a) Inheritance of traits in Humans - Pedigree analysis (Nail Patella Syndrome and ABO locus), genetic disorders in humans - autosomal recessive - ADA deficiency, Sickle cell anaemia; autosomal dominant – Huntington's chorea, familial hypercholesterolemia; inborn errors of metabolism - phenylketonuria, Alkaptonuria, Albinism.

b) 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 (14 hrs)

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

b) 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);
c) 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 (36 hrs)

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.

References

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PLANT BREEDING (18 hrs)

Module 4 (8 hrs)
(a) Objectives of plant breeding, important achievements and future prospects. Genetic variability and its role in plant breeding.
(b) Domestication and centers of origin of cultivated plants.
(c) Reproductive systems and pollination control mechanisms; Sexual reproduction - Cross and self-pollination; asexual reproduction, Incompatibility and Male sterility, their types.
(d) Hybridization - role and methods, Inter-varietal, inter specific and inter generic crosses. Back-cross breeding. Heterosis, Inbreeding depression.

Module 5 (10 hrs)

(a) 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.

(b) 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 mutations in Plant Breeding.

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

Practical (9 hrs)

1. Hybridization techniques in self- and cross-pollinated plants.
2. Visit a plant breeding station to familiarize with breeding programmes. Submit a report of the visit.

References

1. Allard R W (1999). *Principles of Plant Breeding*. John Wiley and Sons, Inc.
2. Ghahal G S and Gosal S S (2002). *Principles and procedures of Plant Breeding*. Narosa Publishing House.
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8. Swarup, S., Cargill, E. J., Crosby, K., Flagel, L., Kniskern, J., & Glenn, K. C. (2021). Genetic diversity is indispensable for plant breeding to improve crops. *Crop Science*, *61*(2), 839-852.
9. Xiong, W., Reynolds, M., & Xu, Y. (2022). Climate change challenges plant breeding. *Current Opinion in Plant Biology*, *70*, 102308.
10. Yali, W., & Mitiku, T. (2022). Mutation breeding and its importance in modern plant breeding. *Journal of Plant Sciences*, 10(2), 64-70.

HORTICULTURE (18 hrs)

Module 6 (18 hrs)

(a) Introduction to Horticulture; nature and scope. Objectives of horticulture.

(b) 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.

(c) 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.
(d) Floriculture: 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.
(e) Bonsai: Selection of plants and making of bonsai. Physical control of plant growth in Bonsai preparation. Preparation of terrarium, aquaponics and arboriculture. Components of high-tech farming.

Practical (9 Hrs)

1. Identify the types of gardens.
2. Demonstration of Preparation of a Terrarium.
3. Propagation methods-layering and grafting.

References

1. Adam C.R. (2004). Principles of Horticulture. Elsevier Butterworth-Heinemann.
2. Bose TK, Maiti RG, Dhua RS & Das P. (1999). *Floriculture and Landscaping*. Naya Prokash.
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PG25BO311: ANGIOSPERM TAXONOMY, ECONOMIC BOTANY AND ETHNOBOTANY

(Theory 63+9 Hrs; Practical 63 Hrs; Credits: 4)

COURSE OUTCOMES (CO)

CO No.	EXPECTED COURSE OUTCOME Upon completion of this course, the students will be able to	Knowledge Level	PSO No.
1	Identify and compare morphological and structural characters of flowers and fruits.	K3	1
2	Develop a comprehensive understanding of the anatomical, biochemical, cytological and molecular techniques used in plant systematics.	K2	2
3	Comprehend the major plant classification systems and utilize this knowledge to analyze taxonomic literature and construct and interpret taxonomic keys.	K3	1, 2
4	Explain the principles and rules of plant nomenclature	K2	1
5	Identify and classify flowering plants to respective families based on diagnostic characters	K3, K4	1,6
6	Develop skills in identifying the plant derived products and analyse their economic and ethnobotanical significance.	K3, K4	4
Knowledge Levels: K1-Remembering; K2-Understanding; K3-Applying; K4-Analyzing; K5-Evaluating; K6-Creating.			

ANGIOSPERM TAXONOMY (63 hrs)

Module 1 (5 hrs)

Introduction

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

Module 2 (4 hrs)

Data sources of taxonomy

(a) Anatomy: Applications of anatomy in plant systematics

(b) Chemotaxonomy: Applications of chemotaxonomy in systematics; Flavonoids, Alkaloids, Terpenoids.

(c) Cytotaxonomy: Applications of cytotaxonomy in systematics – chromosome number, size, morphology and behaviour at meiosis.

(d) Molecular Taxonomy: DNA barcoding, Applications of DNA Barcoding in Plant Systematics, Basic features of barcoding sequence, barcodes in plants– ITS, rbcL, matK,

Module 3 (8 hrs)

Classification and Methodology of Identification of plants

(a) Systems of classification: Artificial system of classification, Bentham & Hooker‟s System, APG IV system (brief study)

(b) Taxonomic literatures: Floras, e-flora, Monographs, Revisions, Manuals, Indices, Journals.
(c) Updated version of floral formula
(d) Taxonomic key - Indented and bracketed key

Module 4 (10 hrs)

Taxonomic structure: Hierarchy, concept of taxa: Species, genus, family

(a) Tools of Taxonomy: Field study, Herbarium techniques, Virtual herbarium, Important Botanical gardens; BSI.

Rules of Nomenclature**: (**a) Madrid code 2025– key features, principles

(b) Basic concepts and terms-: taxon, nothotaxon, protologue, legitimate name, correct name, homonym, autonym, isonym, basionym, tautonym, replacement name, synonym- homotypic and heterotypic

(c) Author citation - single author and multiple authors

(d) Type concept; Holotype, Isotype, Syntype, Paratype, Lectotype, Neotype, Epitype, and Topotype**.**

(e) Retention, Rejection and changing of names - Nomen nudum, Tautonym, Later homonym, Nomen superfluum, Nomen ambiguum, Later isonym, Nomen confusum, Nomen dubium; Conservation of Names

(f) Publication of names- Formulation, Diagnosis; Typification; Effective and valid publication

(g) Principles of priority.

Module 5 (36 hrs)

Angiosperm Families

Study the following angiosperm families with special reference to their general characters, economic importance, ethnobotany, and evolutionary trends.

Polypetalae	**Gamopetelae**	**Monochlamydeae**	**Monocots**
Magnoliaceae	Rubiaceae	Aristolochiaceae	Orchidaceae
Capparidaceae	Asteraceae	Lauraceae	Dioscoriaceae
Malvaceae	Campanulaceae	Loranthaceae	Zingiberaceae
Rutaceae	Sapotaceae	Euphorbiaceae	Cyperaceae
Rhamnaceae	Myrcinaceae		Poaceae
Fabaceae (Faboideae, Caesalpinioideae and Mimosoideae)	Apocynaceae		
Rosaceae	Asclepiadaceae		
Melastomaceae	Convolvulaceae		
Rhizophoraceae	Solanaceae		
Combretaceae	Scrophulariaceae		
Myrtaceae	Acanthaceae		
Apiaceae	Verbenaceae		
	Lamiaceae		

Module 6 (9 hrs)

Economic Botany

Important Plantation crops of Kerala and brief study on their various products - Rubber, Cardamom, Tea, Coffee, Coconut, Catechu.

Cereals: Rice, wheat, maize, oats.

Millets: Sorghum, Perl millet, Ragi, Italian millet.

Pulses: Pigeon pea, Garden pea, Black gram, Green gram, Bengal gram.

Sugar: Sugar cane.

Fruits: Banana, Mango, Jack fruit, 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.

Gums and Resins: White Damar, Gum Arabic, Asafoetida.

Medicinal plants: Liquorice, Indian Sarsaparilla, Serpentine, Turmeric, Asoka tree, Vasaka, Indian Aloe, Belleric Myrobalan, Chebulic myrobalan, Neem.

Ethnobotany

Indian knowledge system - Plants used by tribal people of Kerala: *Trichopus zeylanicus, Ochlandra travancorica, Calamus rotang, Emilia sonchifolia, Curcuma longa, Coscinium fenestratum*. Uses and applications.

Practical (63 hrs)

1. Identify the given plant species from the following families up to species level using the given family key and The Flora of the Presidency of Madras (Gamble, 192). Prepare the key to species for each specimen and draw the flower L.S, floral diagram and write the floral formula. The students should prepare geotagged images of the habit, inflorescence, single flower, flower L.S, androecium, and the gynoecium of the given plant species.

1.Capparidaceae 2. Malvaceae 3. Rhamnaceae 4. Fabaceae 5. Caesalpiniaceae 6.Mimosaceae 7.Rosaceae 8. Melastomataceae 9. Rhizophoraceae 10. Combretaceae 11. Myrtaceae 12.Apiaceae. 13.Rubiaceae 14. Asteraceae 15. Campanulaceae 16. Sapotaceae 17.Apocynaceae 18. Asclepiadaceae 19. Convolvulaceae 20. Solanaceae 21. Scrophulariaceae 22. Acanthaceae 23.Verbenaceae 24.Lamiaceae. 25.Aristolochiaceae 26. Loranthaceae 27. Euphorbiaceae

2. Preparation of indented and bracketed keys for at least 8 species from any two angiosperm families mentioned in the practical syllabus.

3. Work out the given nomenclature problems.

4. Field Study: The students are expected to conduct field study for not less than five days under the guidance of the course teacher and submit the field report for evaluation during practical exam.

5. Prepare fifteen herbarium specimens and submit it along with field book for evaluation during practical exam.

6. Collect and identify economically and ethnobotanically significant plant products mentioned in the syllabus

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PG25BO312: MOLECULAR BIOLOGY
(Theory 54 Hrs; Practical 27 Hrs; Credits 3)

COURSE OUTCOMES (CO)

CO No.	EXPECTED COURSE OUTCOME Upon completion of this course, the students will be able to	Knowledge Level	PSO No.
1	Understand the structure and types of DNA and RNA	K2	2, 4
2	Analyze the chromatin organization and chromosome structure.	K4	2, 4
3	Analyze DNA replication and repair mechanisms.	K4	2, 4, 5
4	Understand transcription and post-transcriptional modifications	K2	2 ,4, 5
5	Analyse the mechanism of translation in prokaryotes and eukaryotes	K4	2, 4, 5
6	Examine transcriptional and post-transcriptional regulations	K3	2, 5
Knowledge Levels: K1-Remembering; K2-Understanding; K3-Applying; K4-Analyzing; K5-Evaluating; K6-Creating.			

Module 1 (8 hrs)

(a) Griffith's Experiment (1928) - The Transformation Principle; Avery, MacLeod, and McCarty's Experiment (1944) - Identifying DNA as the Transforming Principle; Hershey-Chase Experiment (1952) - Definitive Proof Using Bacteriophages.

(b) Important features of Watson and Crick model of DNA structure, Chargaff"s rules

(c) Alternative conformations of DNA: A-DNA, Z-DNA, C-DNA, E – DNA, triplex DNA and quadruplex DNA, circular and linear DNA, single-stranded DNA.

(d) Structure and function of different types of RNA - mRNA, tRNA, rRNA, SnRNA, and Micro RNA. RNA tertiary structures. Ribozymes – Hammerhead ribozyme

Module 2 (6 hrs)

(a) c-value paradox, DNA renaturation kinetics, Tm, Cot curve. Unique and Repetitive DNA – mini- and microsatellites.

(b) Structure of chromatin and chromosomes - histones and nonhistone proteins, nucleosomal organization of chromatin, higher levels of chromatin structure. Heterochromatin and Euchromatin, formation of heterochromatin. Chromosomal packing and structure of metaphase chromosome. Molecular structure of the Centromere and Telomere.

Module 3 (10 hrs)

(a) DNA replication: Unit of replication, enzymes and proteins involved in replication (in both procaryotes and eucaryotes). Structure of the replication origin (in both procaryotes and eucaryotes), priming (in both procaryotes and eucaryotes), replication fork, fidelity of replication. Process of replication – initiation, elongation and termination. Replication in the telomere - telomerase. DNA replication inhibitors

(b) Direct repair: Mismatch repair Excision repair – base excision repair and nucleotide excision repair, photoreactivation, SOS response – Transletion DNA polymerase.

(c) Recombination: Homologous and nonhomologous recombination, molecular mechanism of homologous recombination. Site-specific recombination.

Module 4 (10 hrs)

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

(b) Transcription in procaryotes: 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.

Module 5 (10 hrs)

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

(b) Translation: Important features of mRNA – ORF, RBS. Fine structure, composition and assembly of procaryotic and eukaryotic ribosomes. tRNA charging, initiator tRNA.

(c) Stages in translation: Initiation – formation of initiation complex in procaryotes and eucaryotes, initiation factors in procaryotes and eucaryotes, 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

(d) 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 6: Control of gene expression (10 hrs)

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

(b) Procaryotic system: Transcription switches, transcription regulators. Regulation of transcription 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.

(c) Eucaryotic system: Changes in chromatin and DNA structure – chromatin compaction, transcriptional activators and repressors involved in chromatin remodelling, 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, RNA interference, micro-RNA. Role of small RNA in hetero chromatization and gene silencing

Practical (12 hrs)

1. Work out problems related to DNA structure and replication.
2. Work out problems based on gene expression and the genetic code.

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SEMESTER IV

Elective Group	Course Code	Course Title	Teaching Hrs Theory	Teaching Hrs Practical	Credits
Group I – Biotechnology (Offered by the Department)	PG25BO413	Elective - Plant tissue culture and Microbial Biotechnology	90	72	4
	PG25BO414	Elective - Genetic Engineering	90	54	4
	PG25BO415	Elective - Genomics, Transcriptomics, Proteomics and Bioinformatics	90	54	4
	PG25BOP7	Practical of Plant tissue culture and Microbial Biotechnology			2
	PG25BOP8	Practical of Genetic Engineering & Genomics, Transcriptomics, Proteomics and Bioinformatics			2
Group II - Microbiology	PG25BO416	Food, Agriculture and Environmental Microbiology	90	72	4
	PG25BO417	Clinical Microbiology	90	54	4
	PG25BO418	Industrial Microbiology	90	54	4
	PG25BOP9	Practical of Food, Agriculture and Environmental Microbiology			
	PG25BOP10	Practical of Clinical Microbiology & Industrial Microbiology			
Group III – Environmental Science	PG25BO419	Basic concepts in Environmental Studies	90	72	4
	PG25BO420	Natural resources and their management	90	54	4
	PG25BO421	Environmental monitoring and management	90	54	4
	PG25BOP11	Practical of Basic concepts in Environmental Studies			
	PG25BOP12	Practical of Natural resources and their management & Environmental monitoring and management			
	PG25BO4P	Project			4
	PG25BO4V	Comprehensive viva voce			3
		Total for Semester IV			***23***

PROGRAMME ELECTIVE I - BIOTECHNOLOGY

PG25BO413: PLANT TISSUE CULTURE AND MICROBIAL BIOTECHNOLOGY
(Theory 90 hrs; Practical 72 hrs; Credits 4)

CO. No.	EXPECTED COURSE OUTCOME Upon completion of this course, the students will be able to	Knowledge Level	PSO No.
1	Explain regeneration methods in tissue culture.	K2	2,4
2	Understand somaclonal variation, its mechanisms, and applications in plant breeding.	K2, K3	2,4
3	Explain the methods and applications of haploid and triploid plant production and evaluate germplasm conservation techniques.	K2, K5	2,6
4	Understand protoplast isolation, culture, and fusion methods and explain the production of secondary metabolites from hairy root culture.	K2	2,4
5	Evaluate the use of microbes in industry and medicine.	K5	2,4
6	Explain immobilization techniques, tissue engineering, and bioremediation strategies.	K2	4,6
Knowledge Levels: K1-Remembering; K2-Understanding; K3-Applying; K4-Analyzing; K5-Evaluating; K6-Creating			

Module 1 (12 hrs)

(a) Adventitious regeneration: Direct regeneration, indirect regeneration. Factors influencing adventitious regeneration; genotype, explant – orientation of explant, position on mother plant.

(b) Somatic embryogenesis: General aspects, initiation of embryogenic cultures, maturation of somatic embryos, regeneration of plants, factors regulating somatic embryogenesis, differences between somatic and zygotic embryos. Encapsulation of somatic embryos, synthetic seed production; desiccated and hydrated types. Applications and limitations of synthetic seeds.

Module 2 (12 hrs)

Somaclonal variation: Isolation of somaclonal variants, molecular basis of somaclonal variation. Origin of somaclonal variation – pre-existing variability, *in vitro* induced variability; Reasons – changes in ploidy level, changes in chromosome structure, gene mutations, gene amplifications, changes in extra nuclear genes, activation of transposable elements, DNA methylation. Applications of somaclonal variation.

Module 3 (18 hrs)

(a) Haploids: Androgenesis - pretreatment of anther/pollen grains, media and growth regulators, Induction and stage of pollen development, regeneration, androgenic embryos, factors affecting androgenesis. Microspore culture - protocol, advantages over anther culture.

(b) 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.

Germplasm conservation: Importance, methods of conservation: *In situ* and *ex situ* conservation. *In vitro* conservation, short- and medium-term storage, cryopreservation technique – importance of cryopreservation, pretreatment, freezing methods, cryoprotectants, vitrification.

Module 4 (12 hrs)

(a) Isolation and purification of protoplasts, culture of protoplasts, cell division and callus formation, plant regeneration.

(b) Protoplast fusion (somatic hybridization) – chemical, mechanical, electrofusion. Selection, isolation of heterokaryons, cybrids and their applications. Applications of protoplast culture.

(c) Production of secondary metabolites: Culture conditions for producing secondary metabolites, selection of high yielding lines, elicitation, immobilization of cells. Hairy root culture – advantages of using hairy root culture, establishment of hairy root culture and production of secondary metabolites.

Module 5 (18 hrs)

Screening of microbes for metabolite production. Selection of media, sterilization of media. 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. Large scale production of antibiotics - penicillin, industrial chemicals - ethanol, acetone, butanol, lysine. Microbial insecticides. Commercial production of enzymes and their uses - amylase, cellulase, polygalacturonase.

Module 6 (18 hrs)

(a) Cell immobilization: Methods, advantages and applications. Enzyme immobilization: Preparation, applications, enzymes as biosensors. Enzyme engineering.

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

(b) Bioremediation: Importance and advantages of bioremediation, bioaugmentation, pollutants that can be cleaned. Cleaning reactions - aerobic and anaerobic biodegradation, organisms used for bioremediation, cleaning strategies for water and soil - *in situ* and *ex situ* technologies. Bioremediation of radioactive wastes. Phytoremediation - importance. Use of GMOs in bioremediation.

Practical (72 hrs)

1. Isolation and fusion of plant protoplasts.
2. Preparation of synthetic seeds.
3. Preparation of selective medium for drought or salinity resistance. Preparation of MS solid medium from stock solutions containing auxin and cytokinin, NaCl or PEG, and inoculation.
4. Cell immobilization.
5. Application of immobilized yeast cells for ethanol production.
6. Isolation of microbes producing amylase.
7. Uninucleate stage of anther and anther culture.
8. Dissect out an embryo from any seed and culture it on a suitable solid medium.

9. Cell plating technique.

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PROGRAMME ELECTIVE - BIOTECHNOLOGY
PG25BO414: GENETIC ENGINEERING
(Theory 90 hrs; Practical 54 hrs; Credits 4)

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome Upon completion of this course, the students will be able to	Knowledge level	PSO No.
1	Demonstrate different tools and techniques in rDNA technology	K2	2,4
2	Describe methods and applications of gene libraries and DNA synthesis	K2	2
3	Interpret plant transformation techniques	K2	5
4	Examine the various aspects of advanced transgenic technology and genome editing and their applications	K4	5
5	Evaluate the applications and apprehensions of rDNA technology	K5	5
6	Explain the approaches and applications in protein engineering and biosensors	K2	2
Knowledge Levels: K1-Remembering; K2-Understanding; K3-Applying; K4-Analyzing; K5-Evaluating; K6-Creating.			

Module 1 (18 hrs)
Tools and Techniques in rDNA technology
(a) Isolation of DNA and RNA from bacteria and plant cells
(b) DNA cutting and modifying enzymes: restriction endonucleases – types, mode of action; alkaline phosphatase, polynucleotide kinase, S1 nuclease, exonucleases, Ligases.
(c) In vitro DNA ligation strategies: Joining with ligases – adaptors, linkers and homopolymer tailing; topoisomerases, and site-specific recombinase
(d) Vectors – necessary properties of a vector, construction, important features and specific uses of vectors: pBR322, pUC, Lambda phage, M13, artificial chromosomes – YAC, BAC, PAC, HAC.
(e) Cloning strategies: Peparation of DNA fragments for cloning. Introduction of recombinant DNA into host cell – preparation of competent host cells, 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 (18 hrs)
(i) Gene library: 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.
(ii) Chemical synthesis of DNA: Phosphodiester, phosphotriester, and phosphite-triester method of DNA synthesis (Brief study only) [9, 10]. Phosphoramidite method, automated DNA synthesis [9, 10, 17]. Artificial genome synthesis [27, 28]. Procedure of cDNA synthesis, reverse transcriptase PCR [16].
Module 3 (10 hrs)
Plant transformation

(a) Agrobacterium tumefaciens mediated gene transfer in plants - details of vector system based on *A. tumefaciens*, binary vector and cointegrate vector [9, 30]. Steps involved in *Agrobacterium* mediated gene transfer to plants [18, 30].

(b) Plant transformation by direct transfer of DNA (Vectorless methods) - microprojectiles, electroporation, microinjection, chemical, lipofection [9, 18, 30].

Module 4 (20 hrs)

(i) Advanced transgenic technology

(a) Inducible expression systems – natural and recombinant

(b) Site-specific recombination – lox p and Cre recombinase

(c) Homologous recombination and gene knock out

(d) Gene silencing using antisense RNA and RNAi

(e) *In vitro* mutagenesis - site-directed mutagenesis

(ii) Genome editing

(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 5 (12 hrs)

Applications of rDNA technology

(a) GM microbes: Bacteria and yeast– production of useful proteins, basic genetic research.

(b) GM animals: In basic research, producing novel proteins; disease studies, prevention and cure diseases.

(c) Transgenic plants: Herbicide, insect and disease resistance, stress resistance. Genetic engineering for increasing nutritional and other novel qualities in plants, pharming. Bt plants, Golden rice, *Flavr Savr* Tomato.

(d) Gene therapy: 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; Ethical issues.

Module 6 (12 hrs)

(i) Protein engineering

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

(ii) Biosensors

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

Practical (54 hrs)

1. Isolation of plant genomic DNA and its quantification.
2. Isolation of plasmids and its purification by minipreparation and midipreparation.
3. Isolation of bacterial genomic DNA and its quantification by using UV spectrophotometer.
4. Separation of DNA by agarose gel electrophoresis.
5. Extraction and quantification of protein by Bradford method.
6. Separation of proteins by PAGE.
7. PCR.

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applied microbiology. Cambridge University Press.
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PROGRAMME ELECTIVE – BIOTECHNOLOGY
PG25BO415: GENOMICS, TRANSCRIPTOMICS, PROTEOMICS AND BIOINFORMATICS
(Theory 90 hrs; Practical 54 hrs; Credits -4)

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome Upon completion of this course, the students will be able to	Knowledge Level	PSO No
1	Compare different genome mapping techniques, by utilizing molecular markers and evaluating their significance in genomics.	K4	2,4
2	Explain genome sequencing methodologies and key findings from major genome projects.	K2	2
3	Apply computational and experimental techniques for genome annotation and utilize comparative genomics approaches to identify genes, analyze evolutionary relationships, and interpret metagenomic data.	K3, K4	2,4,5
4	Illustrate transcriptome and proteome analysis techniques to support genome annotation and functional genomics studies.	K2	2,3,4
5	Apply bioinformatics tools for sequence analysis, gene prediction, structural biology, and molecular phylogeny to interpret biological data.	K3	3,4
6	Understand the ethical, legal, and social implications of genome analysis	K2	6
Knowledge Levels: K1-Remembering; K2-Understanding; K3-Applying; K4-Analyzing; K5 Evaluating; K6-Creating.			

Module 1 (12 hrs)

Genome mapping

(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 (14 hrs)

Genome sequencing

(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 (16 hrs)

Genome annotation & Comparative genomics

(a) Structural annotation: by computer analysis of sequence data and experimental techniques Functional annotation: by computer-based methods and experimental methods

(b) Orthologs and Paralogs, gene identification by comparative genomics, comparative genomics as a tool in evolutionary studies. Metagenomics.

Module 4 (13 hrs)

Transcriptomics & Proteomics

Components of the transcriptome. Methods of transcriptome analysis and its importance in genome annotation. Proteome, proteomics. Protein profiling – steps in protein profiling. Protein sequencing. Protein expression analysis using protein microarray, protein localization using GFP.

Module 5 (27 hrs)

Bioinformatics

(a) 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, PyMOL; 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 modelling.

(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 (8 hrs)

Ethical, legal, and social impact of complete genome analysis

Genome data availability – Problems with public availability of sequence data, privacy concerns, legal problems, gene and DNA sequence patenting, patenting transgenics.

Practical (54 hrs)

1. Blast search with Protein sequence (e.g. Cytochrome Csequence)
2. Blast search with Nucleic Acid Sequence (e.g Magnolia latahensis & Neanderthal man Paleo DNAs)
3. Carry out multiple sequence alignment using the given DNA sequences (CLUSTAL X, MEGA)
4. Phylogenetic tree creation with MEGA, IqTree, RaxML

5. Molecular structure viewing - use of Rasmol (supply structure of a few proteins downloaded from PDB).
6. 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.
7. 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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PROGRAMME ELECTIVE II – MICROBIOLOGY
PG25BO416: FOOD, AGRICULTURAL AND ENVIRONMENTAL MICROBIOLOGY
(Theory 35+20+35 Hrs: Practical 72 Hrs; Credits: 4)

FOOD MICROBIOLOGY (35 hrs)

Module 1 (11 hrs)

(a) Scope of food microbiology. Food as a substrate. Microorganisms and food – Bacteria, Yeasts and Moulds. Factors influencing microbial growth in food (Intrinsic and Extrinsic)

(b) Food Spoilage -General principles underlying food spoilage and contamination. Spoilage of canned food, sugar products, vegetable, fruits, meat and meat products, milk and milk products fish, seafood and poultry.Detection of food spoilage-organoleptic, microbiological and chemical. Culture and non-culture based detection of food spoiling microorganisms.

(c) Principles of food preservation – Asepsis, removal of microorganisms, anaerobic conditions, high and low temperatures, drying, irradiation. Chemical and bio preservatives and food additives.Food packaging & labeling.

Module 2 (24 hrs)

(a) Starter cultures their biochemical activities, production and preservation of the following fermented foods (i) Oriental fermented foods (Soy Sause) (ii) Fermented Milk products-Cheese, yogurt and Indigenous dairy products in India (iii) Alcoholic fermentation by Yeast-Wine (iv) Fermented vegetables – Sauerkra (v) production of apple cider vinegar.

Application of microbial enzymes in food industry. Probiotics-production and applications

(b) Diseases caused by spoiled foods and food additives. Food borne diseases caused by bacteria - Salmonellosis, Gastroenteritis, Shigellosis, Listeriosis, Staphylococcal food poisoning, Botulism, Travellers‟ diarrhoea. Fungal intoxication - Aflatoxin and related components. Virus intoxication.

(c) Factors affecting food quality-composition, spoilage, colorants, additives, nutrients, flavorants and contamination. Food laws and quality control – HACCP, Codex alimentarius, PFA, FPO, MFPO, BIS, AGMARK, ISO22000. Food research organizations/institutes in India.

AGRICULTURAL MICROBIOLOGY (20 Hrs)

Module 3 (14 hrs)

a) Microbes as biofertilizers - bacteria, fungi and algae. Production of biofertilizers - strain selection and preparation of biofertilizers. Microbes producing antimicrobial agents, siderophores.

b) Nitrogen fixing microbes – free living organotrophs, free living prototrophs and diazotrophs. Association of microbes with legumes, nodulation process in legumes; nif gene. Azolla-Anabaena association.

c) Phosphate solubilizers – Bacteria and fungi as phosphate solubilizers. Mycorrhizal relationship – definition, forms and distribution of mycorrhiza. Ecto- and Endomycorrhiza. Vesicular and Arbuscular mycorrhiza, Ericaceous, Orchidaceous mycorrhiza. Physiology Mar Athanasius College (Autonomous), Kothamangalam Scheme and Syllabus of M.Sc. Botany and function of mycorrhiza. Production of mycorrhizal biofertilizers. Root exudates, rhizophere and rhizophere effect.

Module 4 (6 hrs)

Bacterial insecticides - use of Pseudomonas and Bacillus. Viral insecticides. Entomopathogenic fungi. Microbial herbicides

Sustainable agriculture, organic farming, crop rotation and legume planting (brief account)

ENVIRONMENTAL MICROBIOLOGY (35 Hrs)

Module 5 (15 hrs)

Microbial communities and ecosystems: Microbial community dynamics and structure of microbial communities.Microbes in extreme environments: Habitat, biodiversity, adaptive strategies and biotechnological potential of thermophiles and hyperthermophiles, psychrophiles and psychrotrophs, halophiles, acidophiles and alkalophiles.

(a) Methods of studying microbial diversity (Conventional and molecular tools)

(b) Isolation and cultivation of microbes from environment - serial dilution and pour plate method, spread plate method, streak plate method, isolation using selective or enrichment media. Methods of culturing anaerobes.

(c) Culture characteristics of microbes. Bacterial growth curve, staining techniques. Biochemical tests for bacterial identification - carbohydrate fermentation, triple sugar-Iron agar test, IMVIC test, Litmus Milk reactions, Hydrogen sulphide test, Catalase test, Oxidase test.

Module 6 (20 hrs)

(a) Soil as a habitat for microbes. Factors influencing soil microbial growth. Microorganisms and the formation of different soils – tropical soil, temperate soil, bog soil, cold moist area soil, desert soil, geologically heated hyper thermal soil.

(b) Microbes and their role in fresh water, brackish water and marine environments. Contamination of aquatic environment by pathogenic microbes. Detection of coliform bacteria - membrane filtration technique, multiple tube fermentation tests. Quantification of Coliforms - MPN test.

(c) Waste water treatment - primary, secondary and tertiary treatment.

(d) Biogeochemical cycles: Role of microorganisms in Carbon, Nitrogen, Sulfur and Phosphorous cycles. Microbes as pollution indicators. Biological magnification. Role of microbes in the disposal of waste and production of organic compost and biogas. Microbial leaching; microbial biofilm.

(e) Bioremediation - microbial and enzymatic; in situ and ex situ. Microbial bioremediation of petroleum, heavy metals and pesticides. Bio-augmentation – principles, enzymes used in bio-augmentation, bio-filtration-bio-filters, microorganisms used in filters, mechanism of bio-filtration, phyto-extraction and phyto transformation. Genetically modified microbes - benefits and hazards. Metagenomics

Practical (72 hrs)

1. Isolation of microorganisms from different sources – air and water.
2. Isolation of microbes by serial dilution and pour plate/ spread plate method
3. Isolation of microbes by streak plate method
4. Microbiological examination of foods.

(i) Isolation and enumeration of bacteria and fungi from fresh and spoiledfruits.

(ii) Isolation and enumeration of bacteria and fungi from fresh and spoiledvegetables.

(iii) Isolation and enumeration of bacteria from fruit juices.

5. Effect of food preservatives on the growth of microbes.
6. IMVIC test
7. Oxidase test
8. Catalase test
9. Litmus milk test
10. Hydrogen sulphide test
11. Carbohydrate fermentation test
12. Multiple tube fermentation test
13. Methylene blue reductase test for milk
14. Molility by hanging drop method
15. Detection of siderophore production by bacteria
16. Estimation of mycorrihzal colonization in roots
17. Isolation of Azotobacter from soil

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PROGRAMME ELECTIVE II - MICROBIOLOGY
PG25BO417: CLINICAL MICROBIOLOGY
(Theory 90 Hrs + Practical 54 Hrs; Credits: 4)

Module 1: (15 hrs)

Immunology

Cells and organs of immune System- stem cells, lymphoid cells, clinical uses of stem cells. B-lymphocytes, T-lymphocytes. Development of B and T cells. Phagocytosis, Granulocytic cells. Organs of immune system-primary and secondary lymphoid organs.

Module 2: (15 hrs)

Antigens and Antibodies

Types, Basic structure of immunoglobulins, classes of immunoglobulins, B-cell receptors and T-cell receptors. Monoclonal antibodies and clinical uses. Genetically engineered antibodies.

Antigen antibody reactions

Antigen antibody reactions- in vivo and in vitro. Toxin neutralization, immune complex formation, Agglutination, ELISA, immunoblotting, flow cytometry immunofluorescence and radioimmunoassay.

Module 3: (15 hrs)

Immune disorders and therapy

Acute rheumatic fever, type I diabetes mellitus and multiple sclerosis. Interferon, Vaccines, DNA-vaccines, edible vaccines. Autoimmunity- autoimmune diseases. Transplantation immunology-graft rejection and Suppression of graft rejection.

Module 4: (15 hrs)

Diagnosis of Microbial Diseases

Collection, transport and preliminary processing of clinical pathogens. Clinical, Microbiological, Immunological and Molecular Diagnosis of microbial diseases. Modern methods of microbial diagnosis.

Module 5: (15 hrs)

Viral Diseases

(a) Epidemiology of common viral diseases in humans. HIV, Hepatitis B and C, HPV, Nipah(NiV), Ebola (EBOV). Isolation and maintenance of viruses, methods for detection and assay, phage typing.

(b) Anti-viral strategies: Prevention and control of viral diseases: Host specific and nonspecific defense mechanisms (molecular level) involved in resistance to virus infections and recovery. Role of interferon in viral infections. Contributions of various host defense mechanisms in viral infections. Viral Chemotherapy: Nucleoside analogs, reverse transcriptase inhibitors, protease inhibitor

Module 6: (15 hrs)

Bacterial Diseases

(a) Epidemiology of common bacterial diseases in humans.(Diphtheria, cholera, typhoid, meningitis leptospirosis and Campylobacteriosis) Normal microbiota of human body; host-parasite relationship in baterial pathogenicity: non-specific mechanisms of host defense, mechanism of bacterial virulence, genetics of bacterial virulence; chemotherapy.

Antibiotics - origin, classification, chemistry and mode of action; semisynthetic antibiotics. Antibiotic resistance in bacteria, mechanism of antibiotic resistance. Common bacterial vaccines

Fungal and Protozoan Diseases in Humans

Epidemology of common fungal and protozoan diseases in humans. (Malaria, Aspergillosis, Candidiasis and Ringworm).

Practical (54 Hrs)

1. Techniques for collection of clinical specimens for microbiological analysis-Macroscopic, microscopic examination of clinical samples. Culture methodsidentification and antibiotic sensitivity test of isolates
2. Double diffusion agar assay (Ouchterlony technique).
3. Staining of bacteria - Gram staining.
4. Spore staining of bacteria.
5. Staining of capsule in bacteria.
6. Staining of lipid granules in bacteria – Burdon‟s method.
7. Antibiotic sensitivity test for bacteria.
8. Blood grouping

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11. Julius M Cruse, Robert E Lewis. Atlas of immunology.

12. Kuby. Immunology.

13. Bilgrami, Sinhah. Essentials of Microbiology.

14. Purohit. Microbiology: Fundamentals and applications.

15. Pelczar, Chan, Krieg. Microbiology.

PROGRAMME ELECTIVE II- MICROBIOLOGY
PG25BO418: INDUSTRIAL MICROBIOLOGY

(Theory 90 Hrs; Practical 54 Hrs; Credits: 4)

Module 1: (15 hrs)

Introduction to Industrial Microbiology

Historical account of microbes in industrial microbiology, Sources and characters of Industrially potent microbes.

Isolation, Selection and maintenance of microbial strains

Isolation of industrially important microorganisms - primary and secondary screening. Detection and assay of fermentation products -physical-chemical, biological assays. Preservation of microbes – storage at reduced temperature, storage in dehydrated forms.

Module 2: (24 hrs)

Types of fermentation

Industrial fermentations. Types of fermentations. Components of fermentation process, Media for industrial fermentation, sterilization, inoculum preparation, raw materials used inindustrial fermentation media, antifoam agents, Solid substrate fermentation (SSF) - Principles and application, Submerged Fermentation. Aerobic and anaerobic fermentation, Problems in fermentation process and handling.

Bioreactors

Fermentor – parts, design, construction and types, Pneumatically driven, hydrolytically driven, mechanically driven, CSTR, Airlift, Packed Bed, Fluidized Bed, Monitoring and control of fermentors, Control of physical and chemical conditions, online and off line instrumentation, pH, temperature, DO probes. Solid state fermentation.

Module 3: (12 hrs)

Fermentation Process

(a) Sterilization - media, fermenter, air.

(b) Inoculum preparation, inoculation.

(c) Aeration, agitation, pH control, temperature control, antifoam agents.

(d) Process parameter optimization: One factor at a time and statistical optimizations (brief study only).

(e) Scale up of fermentation (lab scale, pilot plant, industrial scale).

Module 4: (12 hrs)

Downstream processing

(a) Separation of microbial cells – Filtration, precipitation, centrifugation.

(b) Cell disruption – liquid shear, freezing-thawing, ultrasonication, osmotic shock, enzyme treatment.

(c) Concentrating and purifying the products - ultrafiltration, crystallization, solvent precipitation, reverse osmosis, chromatography.

Module 5: (20 hrs)

Production of industrially important products

(a) Antibiotics - Penicillin, Streptomycin.

(b) Amino acids - Lysine, Glutamic acid.

(c) Enzymes - Amylase, Cellulase, Pectinase.

(d) Organic acids - Lactic acid, Acetic acid, Gluconic acid.

(e) Biofuels – Bio-ethanol, Bio-butanol.

(f) Biopolymers - PHB, PLA.

(g) Alcoholic beverages - Wine, Beer.

(h) Microbial cells - SCP, Baker‟s yeast.

Module 6: (7 hrs)

Immobilization of cells and enzymes

Methods of cell and enzyme immobilization. Applications of immobilized cells and enzymes.

Practical (54 hrs)

1. Screening and isolation of microbes for production of organic acids and enzymes.
2. Preparation and maintenance of stock cultures (Bacteria and Fungi).
3. Preparation of fungal spore inoculum and enumeration of spores by Hemocytometer.
4. Preparation of bacterial inoculum by measuring OD and enumeration of bacterial cells by serial dilution and pour plate (or spread plate) method.
5. Solid state and Submerged fermentation for amylase (or any other enzyme) production and quantification of product by suitable assay methods.
6. Optimization of process parameters for enzyme production in submerged fermentation.
7. Partial purification of amylase (or any other enzyme) produced by microbial fermentation using acetone precipitation.
8. Lab level production of metabolites (Wine, Vinegar).
9. Immobilization of yeast cells and sugar fermentation using immobilized cells.

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5. Richard G Burns, J Howard Slater. Experimental Microbial Ecology.
6. Arnold L Demain, Julian E Davies. Manual of Industrial Microbiology and Biotechnology.
7. Rita Singh, S K Ghosh. Industrial Biotechnology.
8. John I D‟Souza, S G Killedar. Biotechnology and Fermentation process.
9. Michael J Waites, Neil L Morgan, John S Rockey, Gary Higton. Industrial Microbiology: Anintroduction.
10. A H Patel. Industrial Microbiology.
11. Wulf Crueger, Anneliese Crueger. Biotechnology: A text book of industrial microbiology.
12. B McNeil, L M Harvey. Practical fermentation technology.
13. Henry C Vogel, Celeste L Todaro. Fermentation and biochemical engineering handbook.
14. S C Prescott, Cecil Gordon Dunn. Industrial Microbiology.
15. Mansi EL-Mansi, Charles F A Bryce. Fermentation microbiology and Biotechnology.

PROGRAMME ELECTIVE III – ENVIRONMENTAL SCIENCE
PG25BO419: BASIC CONCEPTS IN ENVIRONMENTAL STUDIES
(Theory 90 Hrs; Practical 72 Hrs; Credits 4)

Module 1: (12 hrs)

History

History of development of environmental science, scope and significance of environmental studies. Concept of the sustainable world.

Natural environment

(a) Origin and structure of earth – primary differentiation and formation of core, mantle, crust, atmosphere and hydrosphere.

(b) Biological environment: Biosphere – hierarchies in the biosphere.

Module 2: (18 hrs)

Earth and its atmosphere

(a) Physical environment: Lithosphere, Hydrosphere, Atmosphere.

(b) Land and water systems: Weathering and erosion process, types and formation of soils and soil profile. Physical, chemical and biological properties of soil. Causes, effects and control of earthquakes, volcanoes, landslides, floods and storms.

(c) Aquatic environment: Hydrologic cycle, diversity of aquatic habitats. Aquatic food web and factors affecting primary productivity. Groundwater – occurrence, chemistry; salt water intrusion.

(d) General characteristics of freshwater environment: Lentic systems; Lakes – origin and classification, ecological zonation, water circulation. Lotic systems - Ecology of streams and rivers.

(e) General characteristics of marine environment: Ocean - chemistry of sea water, circulation and ecological zonation in sea, marine biota, primary productivity, coral reefs and marine resources.

(f) Eutrophication: Causes and consequences, methods of control.

Module 3: (20 hrs)

Weather and Climate

(a) Definitions and scope of climatology, weather and climate. Components of climate system.

(b) Earth‟s thermal environment, Air temperature in relation to altitude. Global circulation of air masses, wind and earth‟s rotation on ocean currents, influence of temperature on moisture content of air, global pattern of precipitation, influence of topography on regional pattern of precipitation.

(c) Classification of climate - Koppen‟s classification and Thornthwaite‟s scheme, climatic types and zones.

(d) Global climatic phenomena - El Nino and La Nina, causes and factors of climate change. Effect of climate change on ecosystems and human life., organisms and microclimate.

(e) Climate of India: Climatic regions of India, Monsoon in Kerala. Short illustration on cyclones affected in peninsular India.

(f) Climate change – causes and effects.

Module 4: (20 hrs)

Ecosystems

(a) Ecosystem organization: Structure and function of ecosystem components. Processes in ecosystem: Primary production – methods of measurement, global pattern, controlling factors. Nutrient cycles, energy flow, biogeochemical cycles, trophic relations, productivity and ecological efficiencies and ecological niche

(b) Structure, function, and characteristics of; (i) Forests and tundras – temperate and tropical forests, arctic and alpine forests (ii) Deserts – arid and semi-arid (iii) Grassland and savannas (iv) Coastal and marine (v) coral reefs (vi) Estuaries: Definition, types, biotic communities and productivity; environmental significance of estuaries. (vii) Mangroves.

(c) Wetlands: Ramsar Convention, Ramsar sites. Different kinds of wetlands: Shallow Freshwater Wetlands, Tropical Marshes, Tropical Swamps, Inland Saline Wetlands, Salt Marshes, Mangrove Swamps, Kol Lands of Kerala. Climate change and wetlands, wetland conservation.

Module 5: (10 hrs)

Community Ecology

(a) Communities: Structure, ecological processes of community formation, ecotone, edge effect types and characters of communities, community gradients. Global pattern of species richness, species diversity.

(b) Dynamics of community development

Module 6: (10 hrs)

Population ecology

(a) Population characteristics, population growth, carrying capacity, population regulation, population differentiation.

(b) Population interactions: Mutualism, proto-cooperation, commensalism, competition, co-existence, predation, herbivory and parasitism

(c) Evaluating the controls on population size. Trends in human population growth. Problems with overpopulation.

Practical (72 hrs)

1. Qualitative and quantitative study of freshwater/marine planktons

2. Soil texture using micrometry from two different sites. Principle and explanation

3. Determination of moisture content.

4. Determination of soil pH from at least three different locations and correlate it with the soil type

5. Determination of chloride, calcium, magnesium, potassium and phosphorous.

6. Estimation of primary productivity in two different aquatic ecosystems and interpretation of the results. Compare the results of Dark and Light bottle method and Chlorophyll method.

7. Study of biodiversity in Forest/Grass land and Pond/River and report the species richness, abundance and animal interactions. Calculate frequency, abundance, evenness and diversity indices.

8. Identification of plants growing in different habitats and studying their adaptations

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PROGRAMME ELECTIVE III – ENVIRONMENTAL SCIENCE
PG25BO420: NATURAL RESOURCES AND THEIR MANAGEMENT
(Theory 90 hrs; Practical 54 hrs; Credits 4)

Module 1: (12 hrs)

Natural resources and their management

Natural resources – renewable and nonrenewable. Preservation, conservation, and restoration of resources. Recycling, reuse, and substitution.

Principles of resource management – Water resources

Distribution of water resources, threats to water resources. Principles and approaches to surface water management, watershed management – catchment infiltration models, rainwater harvesting and storage, recharging of ground water. Management of degraded water resources. Drinking water quality and water treatment - desalination, ion-exchange, reverse osmosis, and disinfection of water.

Module 2: (18 hrs)

Principles of resource management – Energy resources

(a) Energy sources – resource and reserves. Current national and global energy scenario.

(b) Fossil fuels: Oil, Coal, Natural gas, Shale – sources, exploration, exploitation; environmental consequences of overexploitation.

(c) Nuclear energy: Nuclear fission and fusion, nuclear minerals, nuclear fuel cycle, nuclear fuel production, nuclear reactors. Advantages and disadvantages of nuclear power. Environmental consequences – safety, terrorism, waste disposal and management.

(d) Renewable and alternate energy sources; solar energy, photovoltaic cells; hydropower; tidal power; wind power; geothermal energy; ocean energy; fuel cells – advantages and disadvantages, environmental consequences.

(e) Bio-energy: biomass as energy source, biomass production, energy farming, biomass conversion processes – thermochemical and biochemical. Biodiesel. Environmental consequences of biomass resource harnessing.

Principles of resource management – Land resources

Land as a resource, land degradation and its causes, desertification – causes and prevention.

Principles of resource management – Food resources

Food sources, effect of agriculture on the environment. World food problems, methods and strategies to alleviate food problems.

Principles of resource management – Mineral resources

Mineral resources: Formation of mineral deposits. Types of mineral resources, environmental impact of mineral exploration, mining, processing and utilization. Conservation of mineral resources.

Module 3: (20 hrs)

Principles of resource management – Biological resources

(a) Forests as biological resources – importance, types of forests, deforestation, reforestation, conservation of forests.

(b) Biodiversity and its importance: Types of biodiversity - wild biodiversity, agro-biodiversity, domesticated biodiversity. Values of biodiversity, ecosystem functions and biodiversity, mobile links and valuating ecosystem services. Drivers of biodiversity loss. Tools and techniques for biodiversity estimation: Biodiversity indices; methods of biodiversity monitoring.

(c) Uses of biodiversity – source of food, medicine, raw material, aesthetic and cultural values.

(d) Threats to biodiversity; natural and anthropogenic, species extinctions, IUCN threat categories, red data book. Extinction: Types, Causes – population growth, overconsumption, pollution, climate change. Ecological extinction, biological extinction.

(e) Principles and strategies for biodiversity conservation - In-situ conservation: sanctuaries, biosphere reserves, national parks, nature reserves, preservation plots. Ex-situ conservation: botanical gardens, zoos, aquaria, homestead garden; herbarium; In-vitro Conservation: germplasm and gene Bank; tissue culture: pollen and spore bank, DNA bank. GEF-World Bank initiatives. Biodiversity hotspots and their characteristics, global distribution. National and international programmes for biodiversity conservation. CITES and TRAFFIC, Indian Biodiversity Act 2002 and Rules.

Module 4: (15 hrs)

Biological invasions

(a) Biological Invasions: Introduction - Elton‟s hypothesis – Invasion patterns and process - biological attributes for invasion: Reproductive potential, Allelopathy - Phenotypic plasticity - fitness to the new environment. Hypotheses for invasion success: Natural enemy hypothesis - evolution of invasiveness hypothesis, empty niche hypothesis, novel weapon hypothesis, disturbance hypothesis and Propagule pressure hypothesis. Invasive alien species of India (plants and animals).

(b) Impacts and management of invasions: Impacts of exotics on biodiversity, productivity, nutrient cycling. Management: Bio-control programmes, mechanical and chemical control - Positive utilization. Quarantine and EIA of biological invasion.

Module 5: (10 hrs)

Environmental economics

(a) Definition, scope and basic theories of environmental economics; sustainable growth.

(b) Economics of natural resources, environment cost-benefit analysis.

(c) Agricultural development and environment: Modern agriculture and its impact on environment – monoculture plantations, use of insecticides, pesticides, chemical fertilizers, hybrid seeds, water consumption, watershed problem, soil erosion, deforestation, desertification, depletion of biodiversity. Sustainable agriculture – alternate methods in agriculture.

(d) Industrial development and environment: impact of modern large scale industries on environment, problems related to modernization and urbanization. Green policies of industrialization.

Module 6: (15 hrs)

Society and Environment

(a) Social perspectives of environment – Global and Indian issues.

(b) Social impacts of growing human population and affluence, production and distribution of food, hunger, poverty, malnutrition, famine.

(c) Social impacts of water crisis, global climate change, ozone depletion, nuclear accidents, acid rain, consumerism and waste products.

(d) Problems related to major dams and other developmental projects, resettlement and rehabilitation.

(e) Environment and human health – epidemiological issues.

Environmental ethics

Importance and need of environmental ethics. Moral relation among humans, nonhumans, and natural environment. Position of humans in the world, human responsibility to care the world, animal rights.

Practical (54 hrs)

1. Water Quality Analysis:

a. Determination pH, Electrical conductivity, Alkalinity, Salinity, Hardness, Nitrate, Phosphate and Silica.

b. Determination of total dissolved salts (TDS).

2. Toxicity Analysis of Water: For Chlorine, H2S, Ammonia, Copper and Chromium.

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PROGRAMME ELECTIVE III – ENVIRONMENTAL SCIENCE
PG25BO421: ENVIRONMENTAL MONITORING AND MANAGEMENT
(Theory 90 Hrs; Practical 54 Hrs; Credits 4)

Module 1: (12 hrs)

Environmental Management

(a) Concepts, strategies and basic principles of environment management. Management of physical, social, and economic environment. Concepts and scope of environmental planning, regional planning and management. Cost-benefit analysis and Resource economics.

(b) Environmental modeling: Simulation modeling, input-output modeling, Linear programming, Software and resource management.

(c) Tool box for environmental management – An overview of Ecological foot prints, carbon footprints, SEA, Ecological Economics, conflict resolution strategies. Eco- funds.

(d) Environmental auditing and Standards - Eco labeling and certification, accreditation – need, objectives and benefits; Corporate social responsibility and Corporate environmental responsibility, ISO standards for environmental management systems (EMS) - ISO 14000, green auditing.

Module 2: (18 hrs)

Ecosystem Management

(a) An overview - Population, Resources and Ecosystem management - Exponential growth in human numbers and the implications.

(b) Major management concepts and methodologies: The five basic laws of Ecology and their relevance for ecosystem management; paradigm shifts in the management of Ecosystems - influence of economics in ecology.

(c) Management practices for various ecosystems: grasslands, forests, mountains, wetlands and coastal areas.

(d) Environmental planning and management of; waste lands, reclaimed lands, mining areas, human settlements, industrial lands and agricultural lands.

(e) Eco- restoration/remediation; local knowledge and management systems; environmentally sound management of Biotechnologies; the common property resources and their management.

Solid Waste Management

Municipal solid wastes (MSW) - quantities and characteristics, waste collection and transport, waste processing, resources recovery and recycling, incineration, pyrolysis, aerobic and anaerobic systems-composting, vermicomposting and sanitary landfills and biodigesters (Biogas). Management of plastic and e-waste. Better management strategies (any two model case studies).

Module 3: (20 hrs)

Toxicology

(a) Definition, scope and history of Toxicology, Acute and chronic toxicity, selective toxicity, dose, synergism and antagonism. Teratogenicity, carcinogenicity and mutagenicity

(b) Toxic chemicals in the Environment – Air, water and Soil. Biochemical aspects of As, Cd, Pb, Hg, CO, O3, PAN, pesticides, MIC, Dioxins, Furans and carcinogens in air, Bioaccumulation & biomagnification.

(c) Occupational Toxicology - hazardous chemicals, disorders exposing from chemical exposure at work, assessment of occupational hazards.

(d) Dose-Response relationships: Graded response, quantal response, Time action curves, Threshold Limit value (TLV); LC50; Margin of safety; Toxicity curves; Cumulative toxicity and LD50& CTF.

(e) Toxicity testing: Bioassay – Definition, purpose, criteria for selection of test organism, methodology, estimation of LC50, Limitation and importance of Bioassay.

Environmental Impact Assessment

(a) Introduction, definition, history, aim, principles, concept and scope. Baseline data collection, Methods and steps – Ad hoc method, checklist method, matrices, Map overlays method, network method, index method.

(b) Impact assessment and impact evaluation: E1A Processes, Stages, E1A Statement. Environment management plan - Environmental Risk Assessment- National Policy on EIA.

(a) Life Cycle Assessment (LCA) and its significance.

Module 4: (17 hrs)

Remote Sensing and GIS

(a) Principles and concepts of Remote Sensing. Electromagnetic spectrum; spectral characteristics of surface features (rocks, soils, vegetations, water). Space imaging - Landsat, SPOT, IRS, NOAA, Seasat, ERS, RADARSAT, INSAT. Satellites and their sensors, geometry and radiometry. History and advancement of remote sensing in India, Chandrayaan and MOM,

(b) Digital Image Processing: Principles, Image Rectification and restoration, Image enhancement and Mosaicing. Image classification. Supervised, Unsupervised, Ground truth data

(c) Geographical Information System (GIS): Basic principles and terminologies, Raster and vector data, Topology creation, overlay analysis, Data structure and Digital cartography; Software used in GIS Surveying: Leveling, Triangulation, Geodetic survey; Global Positioning System (GPS) - Basic principles, Applications to environmental studies.

Module 5: (15 hrs)

Environment versus Development

(a) Dominance of man on earth. Limits of growth. Industrial revolution and resource utilization, environmental consequences. Modern agriculture and green Revolution - environmental impacts.

Conflicts of interest - mega developmental projects and issues of 3 Rs, environment and development.

(b) Disaster management, general principles

Sustainable Development

(a) Principles of sustainability - Reliance on solar energy, biodiversity, population control, Sustainability indicators.

(b) Our Common future and the idea of Sustainable Development - Concepts and dimensions. Basic needs - Imperatives relating to sustainable development. Johannesberg Conference 2002 and follow up Conference on sustainable development. Securing Sustainable futures - Millennium development goals and strategies; the earth charter; need and scope for evolving participatory, community based environmental management strategies. Education for sustainability. Building sustainable societies and lifestyles. Environmental concerns in traditional societies.

Module 6: (8 hrs)

Environmental laws and policies

(a) Historical background of environmental law and policy in India.

(b) The salient features of the following acts and rules: The water (Prevention and control of pollution) act, 1974; The air (Prevention and control of pollution) act, 1981; The environmental (Protection) act, 1986; The wildlife protection act, 1972; The forest conservation act, 1980; The biodiversity act, 2002, The noise pollution (Regulation and control) rules, 2000, The Kerala conservation of paddy land and wetland act 2008.

Practical (54 hrs)

1. Estimation of BOD and COD of polluted water.

2. Isolation and Enumeration of microorganisms in soil (TBC or TMC) - Types of Bacteria and fungi.

3. Bacteriological quality testing of water and waste water.

a. Presumptive Coliform test b. Confirmatory Coliform test.

Field Study: (Three/four days) Visit at least one Institution engaged in environment/conservation research and a sanctuary/national park and an industrial/polluted area or any natural ecosystems. Submit a report of the study with photgraphs of the activity.

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Model Question Paper

MAR ATHANASIUS COLLEGE (AUTONOMOUS), KOTHAMANGALAM
M.Sc. Botany (PGCSS) Degree Examination- Semester I
PG25BO102 – Mycology and Crop Pathology
First Semester (2025 Admission Onwards)

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

Section A
(Answer any **8** questions. Each question carries a weight of 1)

1	What are fungus gardens?	[U] [3]
2	Differentiate between rhizomycelium and pseudomycelium.	[An] [1]
3	Describe different types of spore bearing structures seen in myxomycetes.	[U] [2]
4	How do crozier develop in ascomycota fungi?	[An] [2]
5	What are coprophilous fungi? Give an example.	[U] [3]
6	Mention the role of phenolic compounds in plant defence mechanism?	[An] [4]
7	What is a systemic fungicide?	[U] [5]
8	What are the effects of pathogens in host respiration?	[U] [4]
9	How do crop rotation helps in controlling plant diseases?	[An] [5]
10	How can we identify blister blight disease of tea?	[A] [6]

Section B
(Answer any **6** questions. Each question carries a weight 2)

11	How do hyphal modifications help fungi for performing various functions?	[An] [1]
12	Compare the structure of fruiting body in hymenomycetes and gasteromycetes.	[An] [2]
13	Explain post plasmogamy changes leading to ascus development.	[U] [2]
14	Write an account on asexual fruiting bodies produced by Deuteromycotina fungus.	[U] [2]
15	Discuss the role of abiotic factors in causing plant diseases.	[U] [4]
16	Analyse the significance of transgenic approaches in disease control.	[An] [5]
17	Give an account on powdery mildew of rubber.	[U] [6]
18	Discuss the methods of disease transmission through biotic means.	[U] [4]

Section C (Answer any **2** questions. Each question carries a weight of 5)

19	Fungi have evolved numerous symbioses involving diverse kinds of organisms. Justify the statement.	[An] [3]
20	Explain the classification of fungi proposed by Alexopoulos and Mims (1979), elaborating the salient features of each class.	[U] [1]
21	Write an account on induced disease defence mechanism found in plants.	[U] [4]
22	Describe the symptoms, causative agents, control measures and management of diseases of fruits and vegetables.	[U] [6]